CREEL CENSUS ON THE UPPER MISSISSIPPI RIVER

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EXPLANATORY NOTE

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Representatives from the States of Illinois, Iowa, Minnesota, Missouri and Wisconsin and from the United States Fish and Wildlife Service, meeting in December, 1943, formed the Upper Mississippi River Conservation Committee for the purpose of carrying on scientific investigations of the fishery and wildlife resources of the Mississippi River from Caruthersville, Missouri, to Hastings, Minnesota. Field operations were started in 1944.

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service

CREEL CENSUS ON THE UPPER MISSISSIPPI RIVER

By

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Contribution of the Upper Mississippi River
Conservation Committee

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ABSTRACT

Two summer and two winter seasons of creel census on the section of the Upper Mississippi River, between Red Wing, Minnesota, and Dubuque, Iowa, in 1944-46, showed the catch to be about 0.5 fish per hour, with a wide variety of fish represented, crappies, bluegill walleye, and sauger being predominant. The fishery is important especially to the local fishermen. The fishing success was about the same in the winter as in the summer. Wide fluctuations occurred from one locality to another, and from week to week. Fishing success varied from year to year; it was better in 1948-49 than in 1944-46. The catch per hour was influenced by several factors, such as bait, time of day, day of the week, sex of the fisherman, and probably water temperature (in the summer) and depth of snow cover (in the winter). For most practical purposes, and in the interests of economy of data-gathering, the sample size could be reduced; it is suggested that a census conducted on every fifth day would give results reliable enough for practical management purposes.

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CREEK CENSUS ON THE UPPER MISSISSIPPI RIVER

Introduction

History. The Upper Mississippi River Conservation Committee was organized in 1943, for the purpose of making a study of the fish and fishery of the Upper Mississippi River, where it forms a common boundary between the states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Extensive and intensive investigations were conducted from 1944 to 1949 and on a reduced scale since 1950, under the direction of a Technical Committee for Fish. The creel census operations herein reported were carried out under the auspices of this technical committee, and the supervision of the writer.

A creel census was conducted on the Upper Mississippi River in the area between Red Wing, Minnesota, and Dubuque, Iowa, during the summer of 1944, the winter of 1944-45, the summer of 1945, and the winter of 1945-46.

Fishery investigators familiar with the literature on the subject of creel census are aware of both the advantages and shortcomings of this method of estimating a sport fish harvest. The technique can be said to be almost standardized. It is one of the few reliable methods of assaying a sport fish harvest, and in some instances it seems to be the only feasible approach. Even so, it is at best a cumbersome procedure, and an expensive one.

In the present instance, the technical committee deemed the operation a justifiable one. The need was great for concrete knowledge of the game fish yield of the Upper Mississippi River. It was known that this water furnished fishing sport to thousands of people, even in competition with the renowned fishing in lakes and trout streams in the area. But only a general notion was available of the size of the fishery.

Accordingly, a creel census was decided upon, set up, and carried out as hereinafter described. The design was flexible, since the organization of the Mississippi River Survey necessitated the making of field activity plans for a season at a time. Nevertheless, since four successive fishing seasons (two winter seasons and two summer seasons) were involved, the results obtained lend themselves handily to integration, and permit making certain comparisons of the four seasons.

The desirability of a continuation or repetition of the creel census work, in the years after 1946, was readily apparent; but the urgency of other projects of general fishery investigation necessitated the suspension of extensive creel census work.[1/] Therefore, it is only in a rough manner that comparisons of fishing harvest throughout a period of several years can be made. Casual observation indicated that the average fishing success was greater in the years 1948 to 1950 than it was in the period 1944 to 1946, when the creel census here reported was performed. The number of fishermen utilizing the river increased markedly, no doubt partly on account of the better fishing. Therefore, the total game fish harvest increased in a sort of geometric proportion. It is difficult to estimate long-range trends.

In making any comparisons of fishing success factors between the Upper Mississippi River and other fishing areas, it must be remembered that the figures here presented for the Mississippi River may or may not represent averages over a long period of time. Apparently they do not, but instead they show fishing at low ebb. Generally it is futile to compare one fishing area with another in terms of average fishing success, even though these figures may have been faithfully recorded. Modifying factors are many. The kinds of fish entering the respective catches, the sizes and fighting qualities of the fish, the individual preferences of the fishermen, and the day-to-day and season-to-season changes in fishing success, all make it difficult to say categorically that one water is a better place to fish than another. For this reason a complete

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1/ In the years since 1950, a considerable amount of creel census work has been done, mostly in local areas, on the Upper Mississippi River, by the Upper Mississippi River Committee or its member state agencies. Some of this work has been reported in the annual proceedings of the Committee; part of it is yet to be reported.

review of the published literature on creel census, particularly in regard to quantitative results, is not undertaken here.

The Project. In the summer of 1944, creel census operations on the Upper Mississippi River were confined to the area adjacent to La Crosse, Wisconsin. This included most of pool 8 and a good share of pool 7 (the navigation pools on the Upper Mississippi River are described below). The project was carried out in part with the voluntary cooperation of the Badger State Sportsmen's Club of La Cross, and several sporting goods stores and boat liveries. However, the bulk of the data was actually obtained by a creel census clerk working for the Upper Mississippi River Conservation Committee. The field work extended from May 15 to September 30, with some intermittent work in the month of October. Almost the complete summer and fall fishing season was covered.

The winter census of 1944-45 was much more extensive. Five to 6 men were employed, and the river between Bay City, Wisconsin and Prairie du Chien was covered. The duration of this census was from mid-December to the end of February, which period included nearly all of the winter fishing.

The census of the summer 1945 was still more extensive. Eight to 10 field men were employed, and the territory stretched from above Red Wing, Minnesota to Dubuque, Iowa, a river distance of some 225 miles. The period of operations was from early May to the end of October.

Although these 3 successive operations involved different total mileages of territory, they were similar in the degree of coverage. Each operator had a large territory assigned to him, and could not reach each part of it or contact each fisherman on any given day, particularly since the bulk of the fishermen left the river at about the same time toward the close of the day. Therefore, a system of rotation was used whereby the operator worked one fishing spot on one day and another on the next. Although the intent was to maintain this rotation on a random basis, some of the men developed rather set habits of visiting a certain place on a certain day of the week. This procedure likely had the effect of reducing the randomness of the sample, which effect will be discussed further in following sections.

According to the field men, coverage ranged from 30 to 60 percent of the total fishing effort; in general, this figure was confirmed by the airplane fisherman counts. The data obtained represented a good cross section of the total fishing, and by their bulk, comprised a sample from which reasonable accurate averages can be derived.

The census of the winter 1945-46 was reduced in scope to a spot-check procedure. Three field men were employed, stationed at 3 key spots, Lake Pepin, La Cross, and Prairie du Chien. To a much greater degree than in the summer, the winter fishing is concentrated in particular small areas. Thus it was possible for the creel census operation in the winter of 1945-46 to get good day-to-day coverage of any given fishing spot, although the coverage of the entire river was less complete.

Acknowledgment. The help of a great many individuals and agencies is gratefully acknowledged.

The Upper Mississippi River Conservation Committee, consisting of representatives of the states of Minnesota, Wisconsin, Iowa, Illinois and Missouri, and the U. S. Fish and Wildlife Service, sponsored the work and provided for its being carried out. The Conservation Departments of Minnesota, Iowa, and Wisconsin provided the necessary personnel and money.

The Badger State Sportsmen's Club of La Crosse formally participated in the summer census in 1944. Many of the club's officers and members, including particularly Alfred W. Rice and Walter Weigent, assisted in collecting filled field forms. Several boat liveries and resort operators filled out and submitted field blanks. Among these were the Copeland Park Boat Livery, Henry Rybold, and Haderer's Landing, all of La Crosse. Reports also were collected and submitted by some of the sporting goods stores, including especially Doerre's Hardware and the S. & H. Sport Shop of La Crosse. Many individual fishermen filled out blanks voluntarily.

In the summer census of 1945 and the 2 winter censuses, help was obtained from many boat liveries and resorts. Some of these were: Wines' Resort at Harpers Ferry; Camp Lacupolis; Bass Camp; Merrick State Park; Kenny's Boat Livery at Guttenberg; Clements' Barge at Genoa; and many others. Valuable publicity was given to the project by the various newspapers in the river towns.

The men employed as creel census field men deserve special mention. From first to last, these men did a thorough and conscientious job of conducting the census. They worked through irregular hours, without respect of holidays, and in all extremes of weather. Engaged in one or more of the 4 separate projects were: Vilas D. Balk, Harold E. Beck, I. H. Boomer, Leonard Byer, Harold Elser, Laurence Hiner, Ralph Hunt, E B. Kolcinski, Edwin C. Larson, Paul McLaughlin, Walter Myhrom, Robert Sharp, William Sadewasser, and Lloyd Wyman.

Much aid in working out tabulation procedures was given by the personnel of International Business Machines Corporation, particularly by W. G. Ekman of Minneapolis, and P. J. Spinnler of Milwaukee.

Katherine Roeder and Bettie Satek assisted with the computing and tabulating of data; the drafting was done by Orvie Wetzel, Jr.; and stenographic work by Drusilla Linnell.

Description of the Upper Mississippi River

General topography. The term "Upper Mississippi River", as used by the Upper Mississippi River Conservation Committee, refers to that part of the Mississippi River where it forms a common boundary between the states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri; i.e., the stretch of the river between the mouth of the St. Croix River and the mouth of the Ohio River. This is a distance of 810 river miles. The portion of the Upper Mississippi River which is dealt with in this report is the stretch between the Red Wing Dam and Dubuque, Iowa, a river distance of some 225 miles.

Throughout most of this area, the river valley is bordered by abrupt rocky bluffs. The stream is strongly attenuated and there are numerous sloughs and side channels. There are many so-called lakes which are backwaters usually broadly connected with the river. The entire river valley varies from 2 to 10 miles in width, the total width of the water surface (main channel plus subsidiary channels) runs from 1 to 4 miles.

The gradient is small, the total drop in the 225 miles being only 83 feet. The mean discharge at Red Wing is about 2500 c.f.s., and at Dubuque about 4500 c.f.s., there being several good-sized tributaries between. The river discharge, and correspondingly the water level, varies considerably throughout the year. The usual high-water period is in the spring and early summer, with the water level ordinarily being low and stable throughout the late summer, fall, and winter. Because of the small amount of fall in the land, changes in the water level strongly alter the physical characteristics of the sloughs and backwaters. Any given fishing site, therefore, is far from a uniform piece of water the year around.

The fishing activity is well localized at certain sites and many other stretches of water are scarcely utilized for fishing, either because they do not seem to the fishermen to be suitable or because they are difficult of access and are relatively unexplored. Also, simple gregariousness tends to concentrate ice fishermen.

The various topographical types offer a corresponding variety of fishing conditions. These vary from the almost stagnant and usually shallow water of the backwater lakes, to the much deeper and swifter water in the main channel. Water temperatures run about the same course as those in the waters of the general region, except that, throughout the 225 miles of river, the water temperatures at any given time are remarkably uniform.

Turbidity of the water varies from the reasonably clear water of fall and winter to extremely muddy water during flood stage. Soft bottom with much silt and sand deposition is the rule, even in the larger flowing channels. A

quantitatively good bottom fauna exists, however, and forms an important link in the fish food chain.

Navigation pools. There are 26 dams between St. Paul and St. Louis, each of which is capable of shutting off temporarily almost the entire flow of the river. Each of these dams is by-passed by a lock for the use of river traffic. These dams, built in the period 1934-1940, create impoundments, the purpose of which is to provide depth of water for boat passage. The impoundments have a profound effect upon such factors as water levels, current, silt deposition, etc., and therefore upon the fish population and the fishing. An investigation of the changed conditions brought about by impoundments forms an important part of the work of the Mississippi River Fish Survey.

This series of dams furnishes a neat artificial system for designating geographical units of the river, since the dams are numbered. This numbering system has been adapted to the creel census operation and will be used in this report. Briefly, the entire area of the river between any 2 successive dams carries the same number as the lower (downstream) of the 2 dams. Thus, "pool 10" designates the stretch of the river, including all backwaters and side channels contained therein, between dam 9 and dam 10. In the 225 miles of river under discussion here, pools 4, 5, 5A, 6, 7, 8, 9, 10, 11, and part of pools 3 and 12 are included. These pools are very unequal in length and consequently in area. For instance, pools 5 and 5A are about 15 miles and 10 miles long respectively, while pool 10 is 33 miles long and pool 4 is 43 miles long, including the 22 miles of Lake Pepin. Orientation can be obtained by reference to a map of this part of the river, remembering that pool numbers go from upstream to downstream. To spot a few principal localities it may be mentioned that Red Wing is in the upper end of pool 4, Winona is in pool 6, La Crosse is in pool 8, Prairie du Chien is in pool 10, and Dubuque is at the extreme head end of pool 12.

Lake Pepin, although part of the river proper, has many of the properties of an actual lake. It has little current and toward its lower end is up to 30 feet in depth. It has a sigmoid shape and is about 22 miles long by 1 to 3 miles wide. Lake Pepin carries the entire flow of the river, there being no side channels paralleling it.

In order to separate Lake Pepin from the remainder of pool 4, some of which exists as river above and below the lake, it has been assigned an arbitrary number in the pool-numbering system. Throughout this report Lake Pepin is designated as "pool 4-L" and the balance of pool 4 is called "pool 4-R". This is unofficial nomenclature not to be found on maps or charts.

Characteristics of the fishery

Fishing methods. As would be expected on a fishing water of this size and with various types of topography and a variety of fish to be caught, there is a considerable variation in the kinds of tackle and angling methods employed. Almost all of the common types of tackle are used, including cane poles, fly rods, bait casting rods, etc. In quantitative terms, however, at least 90 percent of the fishing is done by "still-fishing" methods, i.e., with a pole and line in the summer and with a simple line rig in the winter. There is a growing tendency however, toward the use of bait and fly casting equipment.

In the matter of bait, the preponderant use is of live bait - usually minnows or angleworms. Artificial baits such as flies, plugs, and spinners, find limited use. Some of the fishing, such as that for carp or for catfish, uses various kinds of so-called natural materials such as dough balls, cheese, "stink baits", blood, shrimp, crayfish, cut fish, etc.

The catch varies both as to quantity and as to kinds of fish with the bait used. For instance, most of the bluegills are caught on worms, while most of the crappies, bass, and walleyes are caught with minnows. Thus the type of bait used by the majority of the fishermen varies from one fishing locality to another in the same pattern that the kinds of fish fished for and taken vary by localities.

Kinds of fish. The Upper Mississippi River offers an amazing variety of sport fishes. In

this lies a good part of its popular appeal as fishing water, the supposition of the fisherman being that if one kind of fish isn't biting he can fish for something else. Especially is this true of the spring and summer fishing; the fall fishing and the ice fishing are limited to fewer varieties. In the total catch in the summer of 1945, some 19 kinds of fish (counting the 2 species of crappie as 1 kind) were recorded. Of these the following 12 kinds were commonly entered on the records: Bluegill (Lepomis macrochirus. An occasional pumpkinseed, Lepomis gibbosus, or green sunfish, Lepomis cyanellus, was caught; and these were entered with the bluegills as "sunfish"), crappie (Pomoxis annularis and Pomoxis nigromaculatus), walleye (Stizostedion vitreum), sauger (Stizostedion canadense), channel catfish (Ictaluris punctatus), flathead catfish (Pilodictus olivaris), bullhead (most commonly Ameiurus nebulosus, but Ameiurus natalis and Ameiurus melas represented), black bass (largemouth bass, Micropterus salmoides, being much more common than smallmouth bass, Micropterus dolomieu), white bass (Morone chrysops), drum (Aplodinotus grunniens), carp (Cyprinus carpio), and yellow perch (Perca flavescens). These are listed roughly in the order of their abundance in the catch. About half of the total catch is made up of bluegill and crappie.

In the fall fishing the emphasis shifts to walleyes and saugers, although bluegills and crappies still bulk large in the catch. Winter fishing is more specialized than summer fishing and involves fewer kinds of fish. In many of the areas, particularly those in pools 6 to 11, most of the winter catch consists almost entirely of bluegills and crappies. In Lake Pepin and the parts of the river adjacent to it, the principal winter fishing is for walleyes and saugers.

Quantitative aspects. The sport fishery on the Mississippi River between Red Wing and Dubuque is one of considerable magnitude and importance even when viewed in comparison with the tremendous amount of fishing on the lakes and streams of Minnesota and Wisconsin. The resident population of the cities and towns along the river is conscious of the recreational opportunities afforded by the Mississippi River and takes advantage thereof. There are many ardent fishermen who use almost every opportunity afforded them to go fishing, and who may be seen out on the water weekend after weekend throughout the entire season. Another class goes fishing on special occasions such as holidays and vacations. Also, the fishing draws heavily upon the sportsmen resident in the counties adjacent to the Mississippi River, even in competition with the fairly good trout fishing which some of these counties afford.

The exact estimation of the total fishing effort and fish harvest is exceedingly difficult. Two quantities are involved: the numbers of fishermen and the average individual catch. As already mentioned, both of these vary from season to season and both can be determined only by costly and tedious procedures, even for a single season. The creel census under present discussion furnishes only a starting point for making estimates.

Some rough estimates of the total fish harvest, for the period 1945-1949, are presented here in order to give an indication of the relative magnitude of the fishery. In this 225-mile stretch of the Mississippi River, the 5 years, 1945 to 1949 had an average of about 150,000 fishermen during the summer season and about 25,000 during each winter season. The summer figures probably rose from about 60,000 in 1945 to about 250,000 per summer in 1948 and 1949. The winter figures held fairly steady, with perhaps some increase in the winters of 1948 and 1949.

During this 5-year period, the total catch for the summer season ran possibly as low as 120,000 fish (in 1945) and possibly as high as 1,000,000 (in 1948 and in 1949). The total winter catch was perhaps 40,000 fish per season from 1945 to 1948, increasing considerably in 1949.

The total water area (at normal water stage) for this stretch of the river is approximately 170,000 acres. A catch of one million fish in a year therefore would mean the removal of about 6 fish per acre. However, the actual fishing is confined to a small proportion of the total water acreage.

Trends. There apparently is a trend toward more and more fishing on the Upper Mississippi River. There are two main factors involved. The first

of these is the general and widespread increase in fishing interest and activity in the country. The other factor applies specifically to the water involved, which has gained considerably in reputation as a fishing area. Rumors of good fishing are a powerful magnet to attract fishermen. This tendency for good fishing to bring about an increase in numbers of fishermen has been mentioned by others, such as Eschmeyer (1942) and Frey and Vike (1941).

Methods

Field operations. The field technique which was used followed in general the conventional method of creel census operation. With the exception of a comparatively few returns which were submitted voluntarily by the fishermen and routed through boat liveries or sporting goods shops, the data were recorded by personal interview with the fishermen by an employee of the survey (or in some instances by a boat livery or resort operator).

In the summer work part of the contacts were made by boat or foot travel and the fishermen were interviewed while fishing. A large percentage of the contacts were made at boat liveries and landings as the fishermen came in from their fishing trips. In the winter work, contacts were made on the ice at the actual fishing site. The winter fishing did not consist entirely of ice fishing however; a small amount of fishing was done in open water below the dams. This open-water fishing has not been separated from ice fishing in the tabulations of the data.

An effort was made to carry out the interviews as nearly as possible at or toward the end of the day's fishing for each individual fisherman, in order to secure information concerning the length of the average fishing period. Since many of the fishermen quit fishing only at the end of the afternoon or (in the summertime) of the evening, a large share of the contacts had to be made late in the afternoon or evening. The field men, however, attempted to make a certain number of contacts in the morning or at mid-day to catch the early-bird fishermen and to secure information regarding variance of fishing success with the time of day. In any event, whether or not the fisherman had concluded fishing for that day, the census clerk recorded only the number of hours that the fisherman had been fishing up to the time of the interview, as well as the parts of the day involved (morning, afternoon or evening). Thus, all of the data can be expressed in terms of catch per fisherman-hour. In the event that the fishing of more than one person was entered on a single census form, as often was the case, someone of the fishing party acted as spokesman for the group.

The necessity of covering several fishing localities each day required the use of considerable travel by automobile, which added to the expense of the operation. Also, a large amount of traveling was done by motorboat which, although slower than an automobile, permitted access to more out-of-the-way fishing spots.

Report forms. A separate field data form was used for each of the 4 separate seasonal projects but in reality these represented only modifications of a generalized form used by many other creel census workers. The changes from one season to the next were mostly in the nature of simplification since it appeared that certain information was relatively nonessential and could be dispensed with in favor of covering more ground.

The principal items on the field form were: the locality and pool number; the date; the time of day fished; the number of men and number of women in the fishing party; the number of hours fished; and the catch in terms of kinds of fish and number of each kind.

The field forms were printed on cards which were carried loose by the field operators and later were assembled in file boxes. An attempt was made to design the printing of this form so that the recorded information could readily be handled by punchcard tabulating technique. This attempt was only partially successful.

Tabulating procedures. Part of the sorting and tabulating of the collected data was done by hand methods and part of it by I. B. M. electric punchcard technique. It was found that a number of serious errors were made during the card-punching process, and therefore much of the electric tabulating work had to be rechecked by hand later.

This led to the conclusion that punchcard tabulation of a set of data such as these is worthwhile only if errors are minimized by use of the punch-verification process.

General figures

Number of returns. Table 1 gives some of the general statistics of the 4 seasons of creel census. Slightly fewer than 500 cards were returned by the census of the summer of 1944. The summer of 1945 being much more extensive, yielded almost 14,000 returns. The two winter seasons averaged about 3,000 cards per season.

The field work of the census (excluding all supervisory work) cost the participating agencies about $10,000. At this rate, each of the 20,000 cards cost approximately 50 cents.

Fishermen, trips, and hours. The 20,000 cards represented a total of about 40,000 fisherman-trips. The numbers of men and women whose fishing activities were recorded are itemized in table 1. Minors of 15 years or older were separated as to sex and included in these figures; children under 14 were not counted.

In the two summers the percentage of women was 14 and 17 respectively. In the winter fishing this figure dropped to 5 percent. Evidently the members of the gentler sex prefer to do their fishing when the weather is less rugged.

Each card represented, on the average, about 1.7 fishermen in the summer fishing, and about 2.3 fishermen in the winter. The difference probably is significant. Winter fishing is a more gregarious sport than is summer fishing. Not only are the fishermen more closely congregated in regard to locality, but also the average "fishing party" (upon which an individual card was based) tends to be larger. The total number of person-hours of fishing (table 1), when divided by the corresponding total numbers of fishermen, give the average hours fished by each person up to the time of the census interview. These figures for average hours per person varied from 3.2 in the winter of 1944-45 and 3.4 in the winter of 1945-46 to 3.7 in the summer of 1945 and 3.9 in the summer of 1944. Probably the average fisherman stays out longer in the summer than in the winter because of the longer hours of daylight and the more easily tolerated weather. Also, the figures given may have been influenced by the fact that in the summer the interview coincided more often with the end of the fishermen's activity for the day. In the winter the interview often was performed on the ice while the fisherman was still active.

The fishing success ratio, expressed either in fish per person (per "fisherman trip") or in fish per person-hour, ran almost identically for the two winter seasons and the summer season of 1945, but was appreciably higher in the summer of 1944 (table 1). However, the figures for the summer of 1944 are for a restricted area. The figures regarding the fishing success will be discussed in much more detail below.

An average catch of around 2 fish per person (per fishing trip) does not make a very showy stringerful. Of course, a certain number of fishermen went home with a respectable catch and occasionally (though very seldom) a "limit" catch of one or more species was recorded. On the other hand, many persons fished a stint of several hours without catching a single fish. For example, in the winter of 1944-45, 37 percent of the total number of fishermen interviewed had caught no fish; 56 percent had caught 1 to 5; 5 percent had caught 5 to 10 each; and only 2 percent had taken more than 10 fish apiece. The corresponding calculations for the other 3 seasons have not been made but it is probable that the figures would run somewhat similar. This percentage of empty creels is about the same as is to be found in some other areas, as shown by the published literature on creel census.

Residence and distance travelled. For the winter of 1944-45, an analysis has been made of the places of residence of the fishermen and the distances travelled to the fishing grounds. As shown in table 2, fishermen residing in at least 120 different places fished in the area under observation at some time during the winter. Lake Pepin alone (pool 4-L) was visited by fishermen from 52 separate addresses.

However, all of the addresses given during the winter 1944-45 were in the 3 states:

Table 1.--General statistics, four seasons of creel census.

	Summer 1944	Winter 1944-45	Summer 1945	Winter 1945-46
Number of Cards	492	3410	13880	2563
Number of Men	755	7483	19452	5438
Number of Women	124	393	3959	283
Number of Fishermen	879	7876	23411	5721
Per cent Men	86%	95%	83%	95%
Per cent Women	14%	5%	17%	5%
Fishermen per Card	1.8	2.3	1.7	2.2
Person-hours	3430	25594	85699	19555
Ave. Hours per Person	3.9	3.2	3.7	3.4
Total Fish	2441	13827	43093	8928
Fish per Person	2.8	1.8	1.8	1.6
Fish per Person-hour	0.71	0.54	0.50	0.46

Table 2.--Residence of fishermen, winter 1944-45.

Fish in Pool	Places Represented
4-R	49
4-L	52
5	15
5A	21
6 & 7	18
8 & 9	9
10	13
Total - Less Duplicates	120

Wisconsin, Minnesota, and Iowa, bordering on the Mississippi River in this area. By contrast, in the summer fishing there was a significant number of addresses given from other states, such as Illinois.

About 10 percent of the fishermen in the winter of 1944-45 were classed as "local" in regard to the place where they were fishing (within walking distance), and another 36 percent came from distances of 1 to 5 miles (table 3). However, many fishermen drove considerable distances to fish. The average (one-way) distance travelled was approximately 11 miles. This means that allowing 2 fishermen per automobile the 7,900 interviewed fishermen drove a total of approximately 85,000 miles.

Catch composition

Species composition of all-over catch. Table 4 shows the species composition of the entire catch recorded for each of the 4 creel census seasons. As explained in the footnotes to table 4 the crappie were not differentiated as to species; the bullheads included 3 separate species; the black bass were not separated as to largemouth and smallmouth; a few yellow bass (Morone interrupta) were recorded with the white bass; and the "all other" classification included a variety of species.

The figures given include only legal-sized fish (at the time of this study there were size limits on most of the species of fish). The fishermen were questioned regarding their catch of under-sized fish; but it is probable that the figures obtained are not reliable, hence no attempt has been made to analyze and tabulate them. In general, however, the numbers of undersized fish taken were not particularly large.

In both the summer and winter fishing the all-over catch was dominated by bluegill and crappie with the various other species following in numbers. Two species of catfish and the 3 species of bullheads appeared in substantial numbers in the summer fishing but were not taken in the winter. Likewise, the drum appeared only in the summer catch. In the winter of 1944-45 a considerable number of shovelnose sturgeon were taken by fishing in the open water below the Dresbach Dam (pool 8). The data of table 4 are recapitulated in table 5 (in a somewhat condensed manner), in the form of percentages of the total. The bluegill-crappie combination made up close to or better than 50 percent of the total in each of the 4 seasons.

Composition by seasons, pools, and localities. Table 5 shows some of the contrast between the summer and winter fishing. Whereas in the summer the percentage of sauger was less than that of walleye, and was only a small part of the total catch, in each of the two winters the percentage of sauger was much larger than that of walleye. Casual observation in the period 1946-50 indicated that the catch of saugers had increased greatly in proportion both to the catch of walleye and to the total catch, and in both the summer and winter fishing. Possibly a few consecutive abundant year-classes of sauger entered the fishery in that period.

The varying proportions of bluegill to crappie (table 5) are perhaps due not so much to a difference between the winter and summer fishing as to the fact that the 4 different censuses were of different territorial extent; some of them included a larger proportion of bluegill-producing water.

The percentage of the total catch represented by northern pike is a small figure (1 to 4 percent). However, considering the size of this species of fish, its importance to the fishery is greater than the figures indicate. Much the same holds true for the black bass catch. Particularly in some localities, catfish and drum are important constituents of the fishery.

The season-to-season changes in the species makeup of the catch for certain selected parts of the river are shown in tables 6 to 8. Table 6 gives the percentage composition of the catch in pool 8 for the 4 seasons. The 2 summers run fairly well parallel as do the 2 winters. The catch of crappie in proportion to that of bluegill was somewhat higher in the winter than in the summer; and the combined catch of the two ran higher in percentage in the winter because the winter catch was restricted to fewer kinds of fish. Sauger in proportion to walleye ran higher

Table 3.--Distance travelled to fish, winter 1944-45.

Distance, Miles	Per cent of Total
Local	10
1 - 5	36
6 - 10	17
11 - 20	17
21 - 40	18
Over 40	2
Average = 11 miles	

Table 4.--Species composition of catch, four seasons.
Numbers of fish recorded.

	Summer 1944	Summer 1945	Winter 1944-45	Winter 1945-46
Bluegill	712	15914	2639	3094
Crappie [1]	956	7834	5849	1141
Walleye	198	4098	1756	1102
Sauger	51	1007	2456	2761
Northern Pike	80	1258	495	113
Channel Catfish	255	2691		
Flathead Catfish	14	466		
Bullhead [2]	50	1532	3	
Black Bass [3]	61	2459	308	563
White Bass [4]	31	2116	33	90
Drum	25	2438		
Carp	3	802	1	
Yellow Perch		308	36	36
All other [5]	5	170	251	28
Total	2441	43093	13827	8928

1) Both black crappie and white crappie.

2) Three species.

3) Both largemouth and smallmouth.

4) Includes a small number of yellow bass.

5) In winter 1944-45, includes 242 sand sturgeon, Pool 8.
In summer, includes bowfin, gar, eel, mooneye, etc.

Table 5.--Percentage species composition.

Species [1]	Summer 1944	Summer 1945	Winter 1944-45	Winter 1945-46
Bluegill	29	37	19	35
Crappie	39	18	42	13
Walleye	8	10	13	12
Sauger	2	2	18	31
Northern Pike	3	3	4	1
Catfish [2]	11	7		
Bullhead	2	4		
Black Bass	2	6	2	6
All other	3	14	2	2
Total	99	101	100	100

1/ See notes for table 4.
2/ Both channel and flathead catfish.

Table 6.--Percentage species composition, Pool 8.

Species 1/	Summer 1944	Summer 1945	Winter 1944-45	Winter 1945-46
Bluegill	30	16	25	34
Crappie	36	28	51	43
Walleye	9	12	4	5
Sauger	3	6	9	14
Northern Pike	4	11	2	2
Catfish	12	15		
All other	5	12	8	1

1/ See notes for tables 4 and 5.

Table 7.--Percentage species composition, Pool 4-L.

Species 1/	Summer 1945	Winter 1944-45	Winter 1945-46
Bluegill	2		
Crappie	2		
Walleye	56	39	28
Sauger	6	60	70
Northern Pike	4	1	1
Catfish	1		
All other	29		1

1/ See notes for tables 4 and 5.

Table 8.--Percentage species composition, Pool 10.

Species [1]	Summer 1945	Winter 1944-45	Winter 1945-46
Bluegill	58	74	68
Crappie	12	5	13
Walleye	1	2	1
Sauger			
Northern Pike	1		1
Catfish	8		
All other [2]	20	19	18

1/ See notes for tables 4 and 5.

2/ Largely black bass in the winter; largely black bass and white bass in the summer. See text.

in the winter than in the summer; and the percentage of northern pike dropped in the winter.

Table 7 shows that for pool 4-L (Lake Pepin) both the summer and winter catch ran largely to walleye and sauger. Here also the proportion of sauger to walleye was much greater in the winter, being about 2:1 in favor of sauger in the winter catch, and 1:9 in the summer catch (1945). The substantial percentage in the "all other" classification in the summer fishery (29 percent) was heavily contributed to by the catch of carp.

The catch of pool 10 (table 8) showed relatively much less fluctuation from summer to winter. In both the summer and winter seasons, well over half of the total catch was bluegill. This reflects the presence of a remarkable bluegill fishery at one particular locality (Winter Creek), which will be discussed in more detail below. Walleye made up a very small part of the catch and the number of sauger was almost zero. In the "all other" category was included a substantial number of black bass. Here again a single locality (in this instance Gremore Lake) was the principal factor. In this lake black bass (largemouth) are caught in goodly numbers in the winter as well as in the summer fishing. This is unusual, there being only a few other localities in the river where black bass are taken by ice fishing.

Tables 9 and 10 give the species percentage composition of the catch by pools for the summer of 1945 and the winter of 1944-45. (The census of the summer of 1944 involved only pool 8 and part of pool 7; and the census of the winter of 1945-46 included only pools 4-L, 8, and 10, the figures for which may be obtained from tables 6 to 8.)

In the summer fishery, bluegill and crappie were important species in all of the pools except pool 4-R and pool 4-L. There was, however, considerable variation in the percentage numbers of these two species from pool to pool. Walleye and sauger proved to be the dominant species for pools 4-R and 4-L but were far below the numbers of bluegill and crappie in the remainder of the pools. Northern pike loomed relatively large in pools 5A to 8; catfish appeared in good numbers in pools 8 to 11; and bullhead came into its own in pool 9 where a heavy local concentration of bullhead caused it to dominate the entire catch. Various other species also showed considerable variation from pool to pool.

In the winter catch (1944-45), as shown in table 10, the bluegill-crappie combination led all other species combined in all pools except pool 4-L (Lake Pepin). Within this combination, however, there was considerable variation in percentage. For instance, pools 4-R, 5A, and 7 produced several times as many crappie as bluegill, while in pool 10, as mentioned above, the winter catch ran very heavily to bluegill. The winter catch of walleye and sauger was almost inconsequential for all of the pools except 4-R and 4-L. Northern pike showed up in their greatest percentage numbers in pools 4-R and 6; and black bass entered the winter fishery in substantial numbers only in pool 10.

Table 11 gives the species composition of the catch (by percentages) for several important localities in the summer of 1945. The localities are grouped in this table according to the species, or species combinations, which dominate the catch. In the localities in Group I the catch was made up largely of the bluegill-crappie combination; the localities of Group II had a catch made up mostly of walleye and sauger; in Group III the catch was mostly of species other than bluegill, crappie, walleye, and sauger; and in Group IV the catch was of mixed species with no clear dominance. Thus, although several general areas tended toward production of a specialized catch (such as walleye and sauger in Lake Pepin), other general areas such as pool 8 and pool 10 offered several kinds of fishing within the area, and varied from one locality to another. Thus in pool 8, Black River produced mostly crappie and bluegill, while Dresbach Dam had a mixed catch; and in pool 10 several localities were of the bluegill-crappie category, and others, such as the "Pool above the Dam", produced catfish or other species. An even greater degree of segregation of localities by catch composition was shown in the winter fishing (1944-45), as listed in table 12. The localities in Lake Pepin (Group C) produced almost no other kinds of fish besides walleye and sauger. Many localities furnished specialized fishing for blue-

Table 9.--Percentage species composition, summer 1945.

Species [1]	Pool									Total (All Pools)
	4-R	4-L	5A	6	7	8	9	10	11	
Bluegill	6	2	33	55	37	16	23	58	12	37
Crappie	2	2	21	15	13	28	7	12	40	18
Walleye	31	56	15	16	17	12	7	1	7	10
Sauger	6	6				6	1		5	2
Northern Pike	2	4	18	7	9	11	2	1		3
Catfish	5	1	3	1	4	15	5	8	9	7
Bullhead	7			1	4	5	37	1	1	4
Black Bass	4	9	4	3	15	1	2	9	2	6
White Bass	3	8	6		1	1	2	8	4	5
Drum	9	2				3	9	1	19	6
All other [2]	26	10				2	5	1	1	3

1/ See notes for tables 4 and 5.
2/ Dominated, in pools 4-R and 4-L, by carp.

Table 10.--Percentage species composition, winter 1944-45.

Species [1]	Pool 4-R	4-L	5A	6	7	8	10	Total (All Pools)
Bluegill	4		2	33	8	25	74	19
Crappie	62		95	55	89	51	5	42
Walleye	13	39			3	4	2	13
Sauger	9	60				9		18
Northern Pike	12	1	1	11		2		4
Black Bass							17	2
All other [2]	1		1			8	2	2

[1] See notes for tables 4 and 5.
[2] Dominated, in pool 8, by sand sturgeon.

Table 11.--Percentage species composition, certain localities, summer 1945.

Group[1]	Pool No.	Locality	Per cent of Catch: Bluegill & Crappie	Walleye & Sauger	All Others	Dominant Species
I	5	Minneiska	75	2	23	Bluegill
	6	Bathhouse Slough	90	2	8	Bluegill
	6	Bartlett Lake	77		23	Bluegill
	8	Black River	81	4	15	Bluegill & Crappie
	10	Ambro Park	80	1	19	Bluegill
	10	Sand Pit	92		8	Bluegill & Crappie
	10	Gremore Lake	80	1	19	Bluegill
	10	R. R. Bridge	77	3	20	Bluegill
	10	Winter Creek	90	2	8	Bluegill
	11	Swift Slough	87		13	Crappie
II	4-R	Red Wing Dam	6	76	16	Walleye
	4-L	Upper Lake Pepin		97	3	Walleye
	6	Dam 5A	4	85	11	Walleye
	7	Trempealeau Dam	2	95	3	Walleye
III	4-R	Red Wing Levee		11	89	Carp
	9	Crooked Creek	30		70	Bullhead
	10	Pool above Dam	5		95	Chan. Catfish
IV	5A	Whitman Dam	18	36	46	-
	8	Dresbach Dam	27	34	39	-
	9	Genoa Dam	21	22	57	-
	11	Twelve-Mile Slough	42	8	50	-
	11	Guttenberg Dam	21	31	48	-

1) In Group I, more than 70% of total is "bluegill plus crappie". In Group II, more than 70% of total is "walleye plus sauger". In Group III, more than 70% is "other than bluegill, crappie, walleye, and sauger". In Group IV, less than 60% of total is any one of above categories.

Table 12.--Percentage species composition, certain localities, winter 1944-45.

Group[1]	Pool No.	Locality	Per cent of Catch			
			Bluegill	Crappie	Walleye & Sauger	All Other
A	6	Bartlett Lake	70	1		29
	10	Winter Creek	100			
B	4-R	Beef Slough	2	75		23
	4-R	Goose Lake	12	85	2	1
	5A	Fountain City Bay	2	95		3
	6	Straight Slough	8	91		1
	7	Trempealeau Spillway	4	93	3	
	8	French Lake		97	2	1
	8	Bank Slough	7	83		10
C	4-L	King's Coulee			100	
	4-L	Lake City			97	3
	4-L	Lacupolis			99	1
	4-L	Central Point			100	
D	4-R	Red Wing Dam		33	60	7
	8	Slough "22"	40	58	1	1
	10	Gremore Lake[2]	23	16		61

1) In Group A, more than 70% of total is "bluegill".
In Group B, more than 70% of total is "crappie".
In Group C, more than 70% of total is "walleye plus sauger".
In Group D, less than 65% of total is any one of above categories, or "all other".

2) In Gremore Lake, 55% of total is black bass.

gill; in particular, the fishery of Winter Creek consisted entirely of this species.

Table 13 gives the same kind of information for some of the localities for the winter fishing, 1945-46. Here again the various localities showed a tendency toward a more specialized fishery than in the summer fishing.

Several abrupt shifts are to be noted. For instance, French Lake produced almost nothing but crappie in 1944-45, but showed up as a bluegill water in 1945-46. On the other hand, Slough "22" produced more crappie in proportion to bluegill in 1945-46 than it did in 1944-45. Changes such as these likely are due to changes in the method of attack. A few good catches of bluegill at the beginning of the winter may instill the idea in the fishermen's minds that good bluegill fishing is to be had in that particular water; and the fishermen in that locality will use worms rather than minnows for bait throughout the remainder of the season; and hence the season's catch will be predominantly bluegill rather than crappie.

Presumably then, the species make-up of the catch, especially in the winter fishing, is a product of the species abundance in a given locality and the type of fishing (i.e., kind of bait) employed. However, in some areas there actually is a comparative scarcity of some kinds of fish. For instance, in Lake Pepin the game fish population runs largely to walleye and sauger; and comparatively few bluegills would be caught even if worms were used for bait. The fishermen through years of experience are fairly well aware of these catch potentialities of the various waters and use fishing methods which are most likely to produce results.

Fishing success

Definition and terms. All discussion of fishing success in this report is in terms of number of fish caught per fisherman-hour of fishing, expressed as decimal fractions. They are averages obtained by dividing a sum of fish by a sum of fisherman-hours.

These figures for fishing success are stated in terms of the total catch of all species regardless of the number of species involved or the predominance of any one or more species. This procedure is necessary since there is no way of breaking down the field data into the amount of fishing effort expended toward the capture of the separate species. In a way, this produces some inequitable and misleading figures. As measured by return in the thrill of capture or in meat for the table, one fish does not always equal another. A 3-pound bass puts up a better fight than a 2-ounce bluegill; and a 35-inch northern pike furnishes more eating than a 10-inch bullhead. However, it must be borne in mind that a good share of the fishing here reported produced a mixed catch, or one running mostly to panfish (bluegill and crappie). Therefore, it is the exceptional rather than the average catch which is composed of unusually large and desirable fish, or of unusually small and undesirable fish. Therefore, the simple expression of fish per hour can be used with a great deal of justification for making various estimates and comparisons of fishing success.

Success by seasons. Table 14 presents a summary of the total numbers of fish caught, the person-hours of fishing, and the average fish per hour, for each of the 4 seasons, pool by pool. The figures for fishing success (average fish per hour) are recapitulated in table 15.

The all-over totals were 0.71 fish per hour for the summer of 1944; 0.50 for the summer of 1945; 0.54 for the winter of 1944-45; and 0.46 for the winter of 1945-46. Although these figures give a rough indication of the general fishing success for these 4 seasons, they are not strictly comparable since each average covers a different combination of pools and localities. The seasonal averages for individual pools varied from 0.24 fish per hour for pool 4-L in the summer of 1945, to 1.10 fish per hour for pool 10 in the winter of 1945-46. Only for one pool for one season was a seasonal average of more than one fish per hour produced; about half of all the individual seasonal averages by pools ran less than 0.50 fish per hour.

Success by localities. The average fishing success by seasons for several selected localities is given in table 16. These figures are of the same general order as the corresponding figures

Table 13.--Percentage species composition, certain localities, winter 1945-46.

Group[1]	Pool No.	Locality	Per cent of Catch			
			Bluegill	Crappie	Walleye & Sauger	All Others
A	8	French Lake	86	11		3
	10	Winter Creek	99			1
B	8	Slough "22"	10	84	3	3
	8	Bank Slough	3	95		2
C	4-L	Lake City			98	2
	4-L	Lacupolis			97	3
	4-L	Central Point			100	
	4-L	Frontenac Point			99	1
D	10	Gremore Lake [2]		39	2	59

1) See footnote 1), table 12.

2) In Gremore Lake, 48% of total is black bass.

Table 14.--Fishing Success, by pools, for four seasons.

Season	Factor	Pool 3	4-R	4-L	5	5A	6	7	8	9	10	11	12	Total
Summer 1944														
	Fish							503	1938					2441
	Hours							728	2702					3430
	Fish/Hour							0.69	0.72					0.71
Winter 1944-45														
	Fish		1916	3320	237	1334	1139	796	3227	141	1717			13827
	Hours		3714	7643	322	2248	3004	855	4949	195	2664			25594
	Fish/Hour		0.52	0.43	-	0.59	0.38	0.93	0.65	-	0.64			0.54
Summer 1945														
	Fish	22	2265	1775	451	1081	3237	928	3198	2127	18575	9119	315	43093
	Hours	160	7883	7399	1056	3774	8137	3544	8652	5114	19529	19376	1075	85699
	Fish/Hour	-	0.29	0.24	0.43	0.29	0.40	0.26	0.37	0.42	0.95	0.47	0.29	0.50
Winter 1945-46														
	Fish			3606					1548		3774			8928
	Hours			13057					3056		3442			19555
	Fish/Hour			0.28					0.51		1.10			0.46

Table 15. -Fishing success, fish per hour, for four seasons.

	Season			
Pool	Summer 1944	Summer 1945	Winter 1944-45	Winter 1945-46
4-R		0.29	0.52	
4-L		0.24	0.43	0.28
5		0.43		
5A		0.29	0.59	
6		0.40	0.38	
7	0.69	0.26	0.93	
8	0.72	0.37	0.65	0.51
9		0.42		
10		0.95	0.64	1.10
11		0.47		
Total - All Pools	0.71	0.50	0.54	0.46

Table 16.--Fishing success, fish per hour, for certain localities.

Pool	Locality	Season			
		Summer 1944	Summer 1945	Winter 1944-45	Winter 1945-46
4-R	Red Wing Dam		0.30	0.40	
4-L	Lacupolis		0.25	0.50	0.22
4-L	Lake City		0.20	0.40	0.32
4-L	Stockholm			0.30	0.24
4-L	Central Point			0.66	0.51
4-L	Frontenac Point			0.41	0.27
4-L	Madsen Point			0.27	0.18
5A	Fountain City Bay		0.28	0.60	
6	Bartlett Lake		0.65	0.38	
8	Dresbach Dam	0.43	0.40	0.80	0.48
8	Black River	0.83	0.60		
8	French Lake			0.24	0.87
8	Slough "22"			0.73	0.51
8	Bank Slough			0.55	0.30
10	Gremore Lake		1.02	0.24	0.43
10	Winter Creek		0.87	3.01	4.60

for the pools. There is one notable exception, however, Winter Creek, which is near Prairie du Chien in pool 10, produced fishing in each of the two winters which averaged from 3 to 10 times better than the fishing at the various other localities. This probably was due to an underground spring, which keeps a fair sized area free from ice throughout the winter. Apparently the bluegills are attracted to and induced to feed in this open water area and hence are easily caught.

Table 17 gives the total numbers of separate localities which were censused in each of the 4 seasons. These numbers are substantial, especially for the summer of 1945 and the winter of 1944-45. Many of the tabulated "localities" were of minor significance in their contributions to general averages, since for many of them less than 100 or 200 fisherman-hours were recorded for an entire season. The complete list of locality names is not given in this report.

In table 17 is listed the numbers of localities, for each of the seasons, with a total of more than 300 hours fishing per locality per season. Fishing success for the localities is given in terms of the range and the mean. The ranges were broad and the deviations large, as shown by the fact that V (= 100σ/ M) runs as high as 44 for the winter of 1944-45, and 76 for the summer of 1945.

These figures are given in terms of total fish per hour, regardless of kinds and sizes of fish. Some of the qualitative aspects (species composition of the catch) for certain of the localities have been discussed above.

Variation throughout the season. Day-to-day fluctuations in the average fishing success (total, all pools) for the summer 1945 are shown in figure 1. As explained above, each field worker usually found it impossible to cover his territory completely on any given day. Therefore, his returns for successive days often represented separate localities or portions of his territory. This factor probably influenced the apparent daily averages for the total area, causing them to vary from day to day more than would have been the case had it been possible to cover all localities every day. The daily averages for the entire season (total all pools) showed a range of from 0.20 to 1.23 fish per hour, with a mean of 0.54 and a standard deviation of 0.21. This gives a fairly high coefficient of variation, V = 39.

To alleviate this effect of daily fluctuation, the graph of figure 1 is constructed with moving averages of fives. Even so, the line still has a jagged appearance. It is difficult to say just how much of this fluctuation from one day to the next is real and how much is due to the circumstance explained above. Hansen (1942) found that for Lake Chautanqua, the periods of good fishing tended to be short, with steep-sided curves. In three Indian lakes, as reported by Ricker (1945), the week-to-week variations throughout the summer were very irregular, and were different for different species. Some of the variations covering a week or more probably are authentic and are tied in with physical factors, although these may be but vaguely evident.

In general, the fishing success ratio from about mid-July on was higher and also subject to more fluctuation than it had been during the early part of the summer. This holds true for most of the entire area, but comes about especially because of the pronounced tendency in this direction of the more down-river parts of the area (i.e., pool 10 and pool 11). This is brought out in figure 2, which shows comparative graphs for pool 4L, pool 10, and the total (all pools). In this figure, weekly rather than daily averages are used, of necessity, since for any given pool the effect of working various days is considerable. During any given week, however, an entire pool was fairly well covered.

The graph for pool 10 follows closely the contours of the graph for the total (all pools). The existence of a definite mathematical correlationship will be pointed out below. On the other hand, the line for pool 4-L is much more steady and level, showing only a minor peak during the mid-July period. These two pools, being some distance apart and very different physiographically, were subject to different sets of physical conditions throughout the season. Furthermore, the fisheries of the 2 pools were of different natures, the catch of pool 4-L being mostly walleye and sauger, while that in pool 10 ran largely to bluegill, crappie, and bass. This difference

Table 17.--Fishing success, four seasons, with ranges and means of week-to-week values.

Season	Number of Localities Sampled	Number of Localities Used in This Table[1]	Fish per hour Range[2]	Mean	σ	V
Summer 1944	17	5	0.43-0.83	-	-	-
Winter 1944-45	51	20	0.24-1.05	0.52	0.23	44
Summer 1945	71	60	0.08-2.04	0.49	0.37	76
Winter 1945-46	17	13	0.18-0.87	0.37	-	-

1) Only localities with total person-hours more than 300.

2) Omitting "Winter Creek", which was 3.01 fish/hour in winter 1944-45, and 4.60 in winter 1945-46.

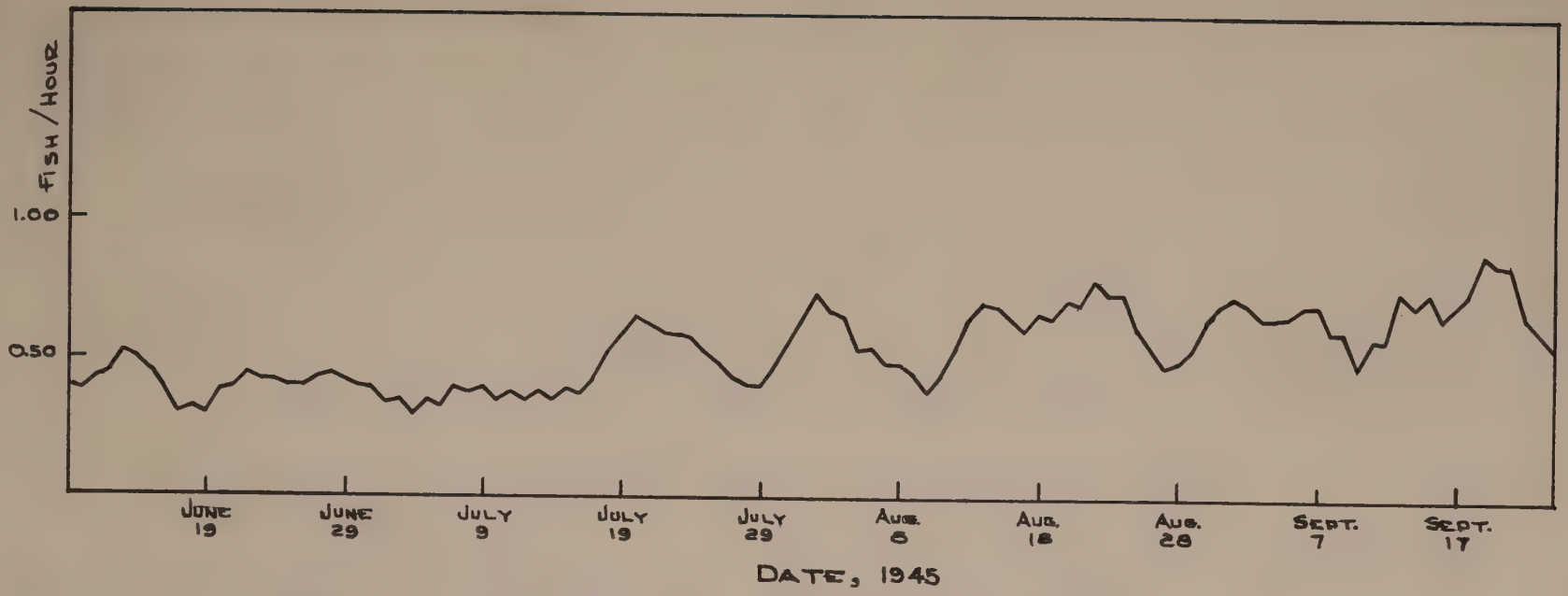

Figure 1. Day-to-day fishing success, summer of 1945 (total, all pools). Curve Smoothed.

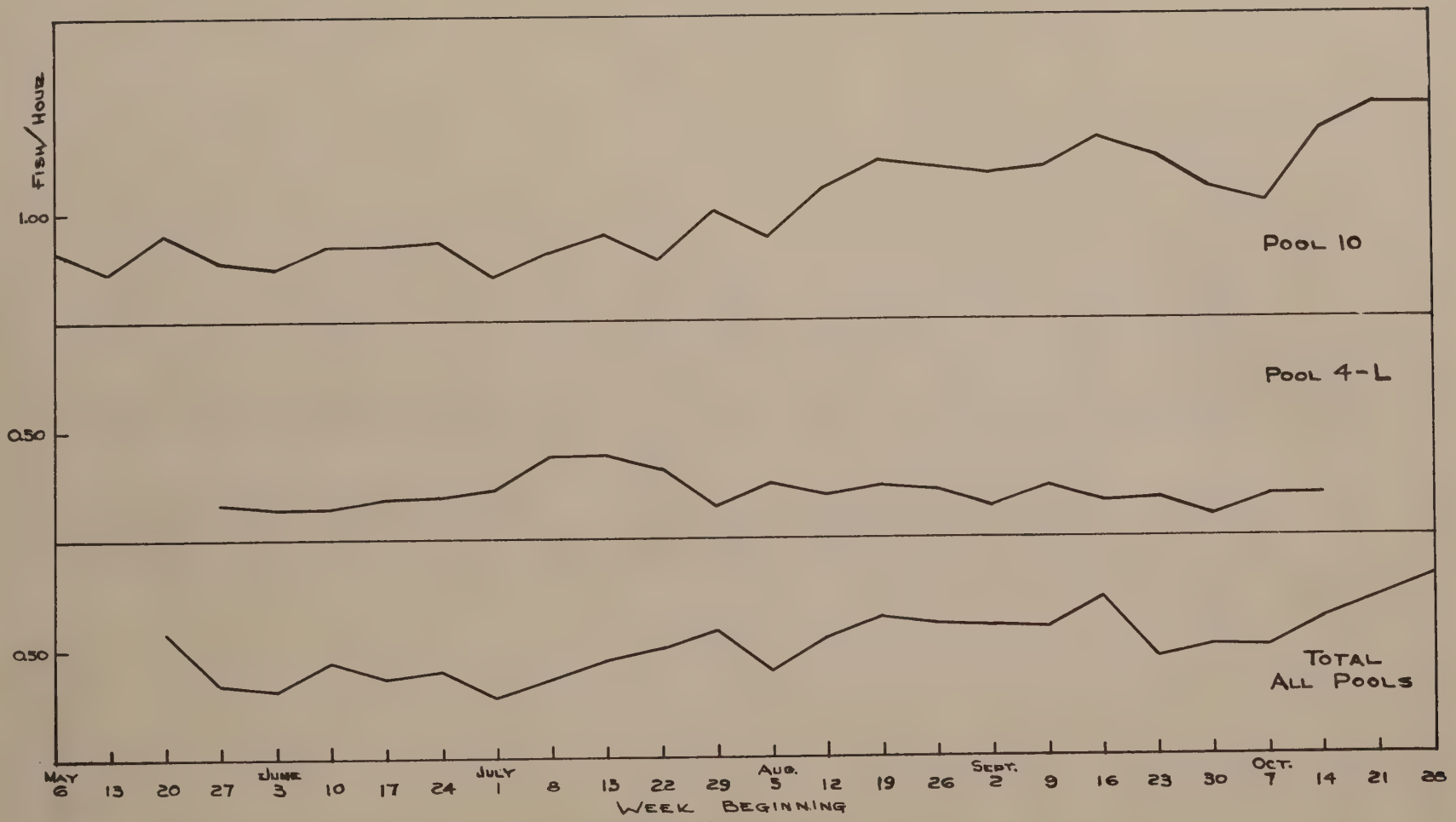

Figure 2. Week-to-week fishing success, summer of 1945. Pool 4-L and Pool 10, and total (all pools).

in the species composition of the catch no doubt influenced the fishing success, and its reaction to the time of season and other physical factors.

Various authors have recorded different times of best fishing. Hiner (1943) found the best fishing of the summer to be had in June (many Minnesota lakes and several species of fish involved). On the other hand, Pelton (1950) reported for Lake Alma, Ohio, that the late summer and fall fishing was better than that of the spring and early summer, except for bass, which was best in June. Hart (1940) found that in one year the fishing for bass in Cache Lake, Ontario, improved after mid-July, but in the following year it fell off. Eschmeyer (1939) stated that in Fife Lake, Michigan, the poorest fishing occurred in mid-season (late July and early August). As Hansen (1942) has said, the peaks of biting may occur at different times for different species, and at different times in different years. Altogether, these records indicate that so many factors are involved, such as water temperatures, species composition, etc., that there can be no general rule as to when is the best time of the year to go fishing.

In table 18 are listed the range and mean of the weekly averages for the summer of 1945, for several of the pools, and a few of the key localities. The fluctuations from the mean were considerable in nearly all instances. A part of this effect may have been caused by the imperfect sampling technique, but a substantial part of it reflects actual fluctuations in fishing success from week to week. These fluctuations are difficult to account for with the information at hand regarding changes in physical factors.

Figure 3 shows the day-to-day changes in fishing success for the total (all pools) for the winter 1944-45. The curve is smoothed by moving averages of fives. The calculated day-to-day averages for the entire winter show a range of from 0.16 to 1.19 fish per hour, with a mean of 0.61, a standard deviation of 0.24, and a coefficient of variation of V = 39.

Some general trends are evident; particularly a fairly steady decline from the beginning of the winter fishing to about the end of January, and a secondary peak in the first few days of February. There was little tendency for the individual pools or localities to follow the total averages in trends throughout the seeson. Therefore, the total averages are composites. Despite this fact, the average does exhibit a seasonal pattern which probably is caused by seasonal changes in physical factors.

Hiner (1943) found that for the Minnesota lakes there was no significant difference between the fishing success in December and that in January. For the sauger fishery in western Lake Erie, Doan (1944) reported a distinctly rising success through the winter season. As with summer fishing, there are many factors which may influence the time of best winter fishing in any given body of water.

Comparison of two years. Figure 4 shows the week-to-week variations in the average (total all pools) for the two winter seasons. Although visual inspection of the two graphs of this figure shows a superficial resemblance, there is only a very weak mathematical correlation ($r = 0.57$; $P = 0.1$). For a sample locality, Gremore Lake (figure 5), the weekly averages for the two seasons followed vaguely similar patterns, but a mathematical correlationship cannot be demonstrated.

The grand total averages for the two winter seasons are 0.54 fish per hour for 1944-45, and 0.46 for 1945-46. Since for each of these seasons the day-to-day or week-to-week deviations from the mean were large, it cannot be proved statistically that there is any significant difference between the two means, or that fishing was any better mathematically in one winter than in the other. However, if from the computation we exclude the small scattered localities with a low number of hours of fishing and use only the 20 and 13 localities, respectively, which are used in table 17, it turns out that there is a mathematically significant difference in the two seasonal means. The means are 0.52 for 1944-45, and 0.37 for 1945-46. Calculations yield a value for d/σ_d equal to 3.0 (for which P is less than 0.005).

A comparison of the two all-over means is perhaps an inaccurate way of comparing fishing successes for the two winters, since the territories involved were of different extent.

Table 18.--Fishing success, certain pools and localities, summer 1945, ranges and means of week-to-week values.

Pool or Location	Fish/Hour Range	Mean
Pool 4-R	0.12 - 0.60	0.28
Pool 4-L	0.10 - 0.39	0.21
Pool 5A	0.04 - 0.58	0.29
Pool 6	0.13 - 0.81	0.42
Pool 8	0.16 - 0.60	0.40
Pool 9	0.14 - 0.88	0.44
Pool 10	0.37 - 1.95	1.01
Pool 11	0.12 - 0.87	0.43
Lacupolis	0.08 - 0.49	0.22
Dresbach Dam	0.12 - 0.69	0.38
Guttenberg Dam	0.21 - 0.77	0.39
Swift Slough	0.07 - 0.87	0.50
Total (all Pools)	0.28 - 0.83	0.52

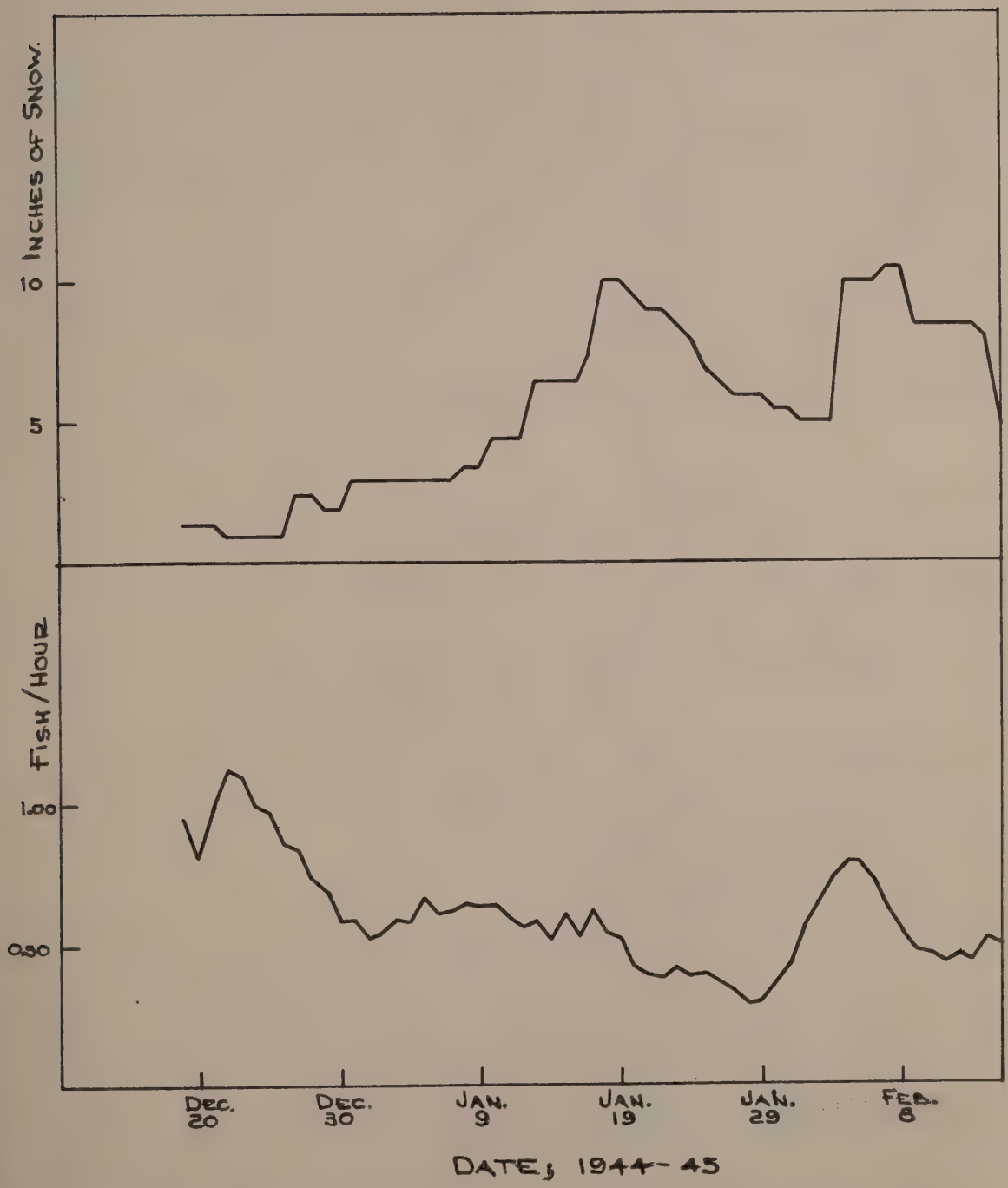

Figure 3. Day-to-day fishing success for all pools for the winter of 1944-45.

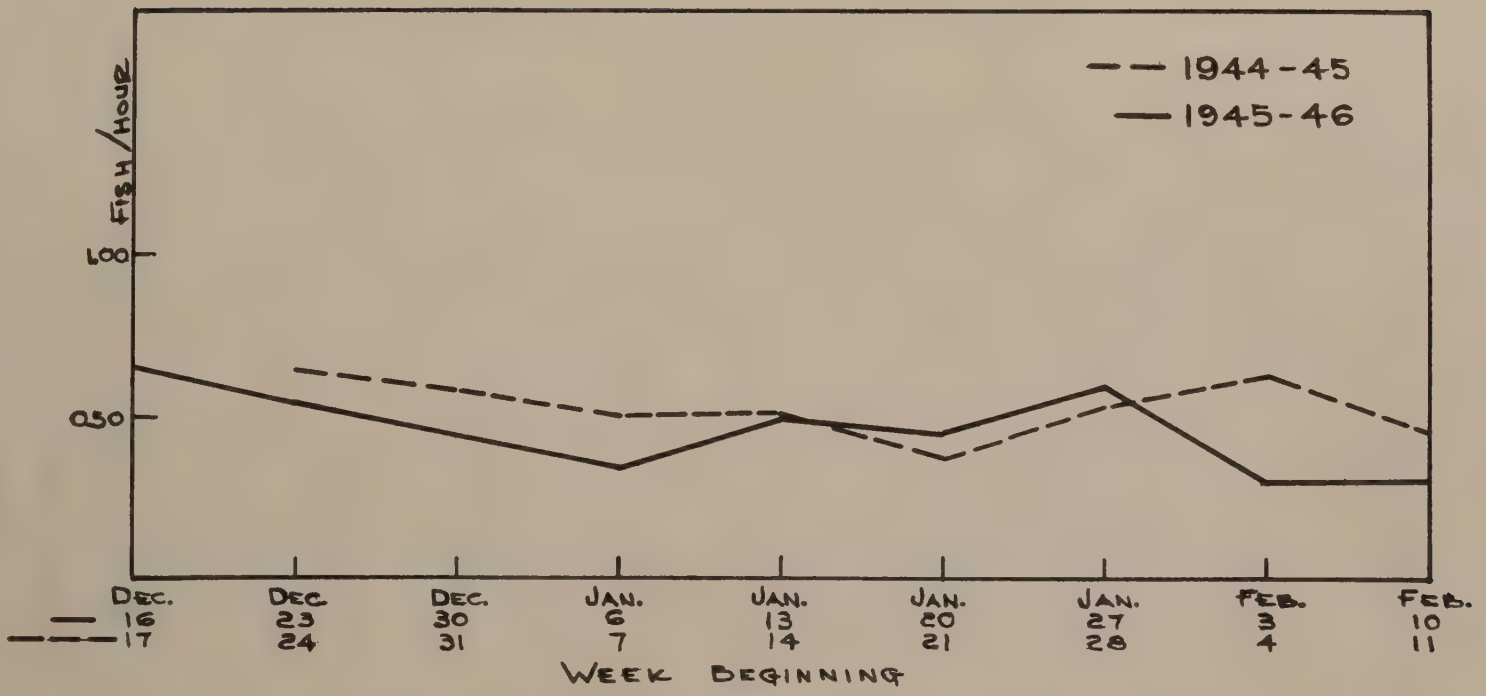

Figure 4. Week-to-week success, winters of 1944-45 and 1945-46 (total, all pools).

Therefore, a comparison has been made of the seasonal averages for 11 localities, each of which was sampled in both winters. These 11 localities are the ones listed for both winters in table 16, except for the omission of Winter Creek. This comparison yields the following figures: the mean for 1944-45 is 0.46; the mean for 1945-46 is 0.39 fish per hour. The value of d/σ_d is 0.9. This is not of statistical significance; and hence it cannot be proved mathematically that the fishing in these localities was better in one of the two winters than in the other.

The week-to-week averages for fishing success for pool 8 in the summers 1944 and 1945 are shown in figure 6. The individual weekly fluctuations in these two curves are large.

The over-all averages for fishing success for the two summer censuses are 0.71 fish per hour for 1944 and 0.50 for 1945. However, since the territory involved was of much greater extent in 1945, the difference between the two mean values has little meaning. From only 3 localities were adequate samples taken in both summers (Dresbach Dam, Onalaska Spillway, and Black River, all in pool 8). The over-all seasonal mean for the total of these 3 localities was 0.63 fish per hour in 1944 and 0.41 in 1945. A comparison of these two means by the method of comparing small samples yields a value of t equal to 1.5 (for which P is somewhat larger than 0.1). The statistical significance therefore is doubtful and it cannot be considered as proven that the fishing in this section of the Mississippi River was better in the summer of 1944 than 1945.

Influence of certain factors

Fishing pressure. Several authors have attempted to show a relationship of the fishing success with the intensity of fishing. Eschmeyer (1942) stated that in Norris Reservoir, Tennessee, the fishing intensity increased for several consecutive seasons without any appreciable decline in catch per hour. In other words, the total take increased. However, in another water (Fife Lake, Michigan), the same author (Eschmeyer, 1939) found the catch per hour to decline through 4 seasons, as the fishing intensity increased. Thus he reasoned that the lake, which was fairly heavily fished, had about a constant available crop from one year to the next.

On the Upper Mississippi River, on the whole it is probable that the fishing pressure has little or no influence upon the catch. The available crop remains large in relation to the annual harvest. At certain places and times, however, the fishing intensity may have a temporary effect. Especially is this true of certain fishing spots where the fishing is concentrated at the beginning of winter. An area of only a few acres may be worked by scores of fishermen day after day if the fish happen to be biting well. In the winter the fish are not moving so much as in the summer, presumably; and what was the catchable population of a small slough or backwater at the onset of ice cover may become fished out in a few days or weeks, resulting in poorer fishing for the remainder of the winter.

Eschmeyer (1942) believed that the decline in the fishing success in Norris Reservoir, after June may have been due largely to the removal of large numbers of fish early in the season. Also in Fife Lake, the same author (Eschmeyer, 1939) attributed the poor fishing in the late summer partly to the early-summer removal of a considerable proportion of the available crop of fish; the remainder found food more available.

Bait. Table 19 shows the fishing success for each of the 4 seasons according to the type of bait used. There is of necessity some lumping of data in this table. For instance, quite commonly a fisherman or a fishing party used both worms and minnows on the same day, and in these cases no attempt was made in the censusing to list separately the amount of fishing effort and number of fish caught for each of the two types of bait. Therefore, a category had to be set up labeled "worms and minnows". Also, the classification "other natural bait" lumps a wide variety (literally dozens of kinds) of baits, ranging from frogs to dough-balls. Because of the relatively small amount of fishing done with any one type of artificial bait, such as plugs, spinners, flies, etc., all of these are placed together in one category.

Table 19.--Fishing success, fish per hour, by type of bait.

Season	Worms	Minnows	Worms and Minnows	Other Natural Baits	Artificial Baits	Total
Summer 1944	0.96	0.63	0.63	-	-	0.71
Summer 1945	0.69	0.33	0.74	0.52	0.29	0.50
Winter 1944-45	1.21	0.49	0.50	-	-	0.54
Winter 1945-46	3.26	0.31	0.76	-	-	0.46

Practically all of the winter fishing was done with worms and minnows to the exclusion of all other types of bait. Except as to bait, no other attempt has been made to classify the various techniques of fishing, i.e., as to kind of tackle or the manner of its use. Also, no distinction has been made between shore fishing and fishing from a boat, or between ice fishing and fishing in the open water in the winter (some open water fishing was done, particularly below dams, but it did not amount to a very large percentage of the whole).

In general, worms produced definitely more fish per hour than did minnows. This was true particularly for the winter of 1945-46, the figures for which were influenced greatly by the very large numbers of bluegills caught on worms at Winter Creek. The figures for artificial baits, and natural baits other than worms or minnows, probably are not very reliable since the amount of fishing involved was not large. The figures, such as they are, show that for the summer of 1945 these types of bait were not as productive in fish per hour as worms and compared not too favorably with the success obtained by using minnows.

In these comparisons it must be remembered that the quality of the catch, both as to species and size, varied greatly with the type of bait used. Worms produced mostly bluegills; the larger fish, such as crappie and walleyes, were caught with minnows.

Time of day. The influence of the time of day at which the fishing was done, upon the fishing success, is shown in table 20. There is of necessity some lumping of information because of the form in which the field data were recorded. For instance, if a fishing party fished throughout the entire day or a large part of it, the census card was made to read "morning and afternoon", "afternoon and evening", or "morning, afternoon, and evening", as the case might be.

With minor disparity, the figures of table 20 show that in both the winter and summer fishing the catch rate was higher in the early and late parts of the day than it was during the midday. To some extent, the morning fishing was the best of all. These conclusions agree well with the general opinion among fishermen, most of whom have heard, or read, or concluded that fishing slacks off in the middle of the day. Despite this belief, however, the daytime fishing intensity is greater than that in the early morning or in the evening; apparently only the inveterate fishermen are willing to start fishing early or stay out late.

Eschmeyer (1935) found much the same situation. Fishing was best at about daybreak and about dusk, although the heaviest fishing load was in the mid-morning and late afternoon. However, Pelton (1950) reported that in Lake Alma, Ohio, "daytime fishing (8 a.m. to 5 p.m.) was nearly twice as good as night fishing."

Sex of fishermen. The numbers of male and female fishermen were recorded on the field forms but part of the data cannot be separated. That is, many cards recorded the fishing of a fishing party containing both men and women without any indication as to what part of the catch was caught by the members of either sex. In the summer fishing for 1944, field cards showing men alone averaged 0.78 fish per hour, while cards with both men and women had an average fishing success of 0.55 (there are too few cards for women alone to justify computing an average). In the winter fishing (1944-45), men alone caught 0.57 fish per hour, parties composed of both men and women caught 0.38, and women alone caught 0.35. The evidence thus is that the men definitely were better fishermen than the women.

Water temperature. There is no doubt that water temperature can and often does exert a considerable influence upon the feeding habits of fish and therefore upon their catchability. However, this influence is apt to be modified or obscured by many other factors so that it is not always plainly evident. Furthermore, in attempting to set up any figures which will demonstrate the relationship of water temperature to fishing success, difficulty is experienced in determining just what measurements should be made and what information should be recorded. For instance, it is not always certain at what water depth the temperature measurement should be made, particularly in a water which is sharply stratified thermally, since fish move freely from one depth to another and are caught at various depths.

Table 20.--Fishing success, fish per hour, by time of day.

Season	Morning	Morning and Afternoon	Afternoon	Evening	Total
Summer 1944	0.81	0.53	0.71	0.80	0.71
Summer 1945	0.52	0.58	0.45	0.48	0.50
Winter 1944-45	0.75	0.44	0.52	0.70	0.54
Winter 1945-46	0.74	0.30	0.46	-	0.46

Furthermore, when a large area is under consideration, water temperature from one place to another may vary considerably. Surface temperatures are under the influence of atmospheric conditions and may change from time to time throughout a given period. Probably for these reasons few authors have attempted to demonstrate correlations between water temperature and recorded catch.

In the summer of 1945, water temperature was recorded somewhat irregularly at several places, all in pool 10. The most complete of these sets of data is that for the locality "Railroad Bridge" at Prairie du Chien. Here the water temperature was measured almost every day from about June 10 to the end of August. These figures are averaged week by week and are presented in table 21. To a reasonable extent, these readings may be used as representative of the water temperature changes throughout most of the entire area. It has been observed during the course of other work on this portion of the river that water temperatures in the various pools, and localities within pools, follow each other closely, at least when the average of a period of several days is considered. Almost everywhere the water is relatively shallow, is subject to some current, and hence is well mixed. There virtually is no vertical stratification and comparatively little prolonged stagnation. The effect of sudden changes in air temperature upon the water surface temperature is largely nullified by the current and wind and wave action. The locality in question (Railroad Bridge) is near to or actually a part of the main flow of the river and hence produces a fairly representative temperature sample.

Table 21 records the weekly fishing success averages for pool 10 and for the total (all pools). As shown by the table, there exists a mathematical correlation between these two sets of averages and the recorded water temperature with a reasonably high degree of statistical significance. Whether this correlation is actually causal or is mostly coincidental may be open to question since there are many other factors which might enter the picture. If the relationship of catch to water temperature, as shown here, is a real one, the import is that within the temperature range here recorded, the higher the temperature the better the fishing. The findings of Dendy (1946), and of Eschmeyer, Manges, and Haslbauer (1946) are to the same effect; i.e., that within a certain range and under a certain combination of circumstances, higher water temperatures favor fishing. However, it has been held by many that extremely warm water may be the cause of the mid-summer slump in fishing which sometimes occurs (perhaps indirectly, by increasing the supply of available food, through the hatching of insects).

Most of the localities, particularly such ones as Lake Pepin, did not show a mathematical correlation of fishing success with water temperature.

Changes in water levels. The moving, feeding, and biting of most of the species of fish in the river are influenced to a certain extent both by the water level and by changes in level (rising and falling). This is the firm belief of most of the sport fishermen and is based upon their observations.

Information based on measurement, such as the daily readings of water level gauges, is difficult to apply to the changes of a large and varied sport fishery. For instance, during the summer of 1945 the hydrographs for the various river stations (constructed from gauge readings) showed a different pattern for the water levels of the different pools, or even sections within pools. Thus it is almost meaningless to attempt to fix upon any mathematical correlations between water levels (or level changes) and fishing success.

Throughout the entire area there was a general trend from relatively high and fluctuating water levels (flood waters) at the beginning of the summer fishing season, to lower and more stabilized levels (normal pool levels) through the latter half of July, August, and September. As shown in figure 1, this change corresponds in time to the increase in amount (also in fluctuability) of the average fishing success. Whether this relationship is a matter of cause and effect or is purely coincidental is open to question.

In the winters of 1944-45 and 1945-46 there occurred some rather drastic changes in

Table 21.—Water temperature and fishing success, week-to-week averages, summer 1945.

Week Beginning	Water Temp. at Prairie du Chien	Fish/Hour Pool 10	Fish/Hour Total (All Pools)
June 10	68	0.69	0.45
17	68	0.69	0.37
24	73	0.73	0.41
July 1	72	0.41	0.28
8	72	0.63	0.37
15	73	0.79	0.45
22	79	0.55	0.50
29	79	1.01	0.58
Aug. 5	79	0.74	0.40
12	80	1.21	0.55
19	80	1.44	0.65
26	79	1.33	0.62

Correlation Pool 10 with water temperature:

$r = 0.62$ $(P = 0.04)$

Correlation Total with water temperature at Prairie du Chien:

$r = 0.70$ $(P = 0.01)$

the water level of some of the pools, caused by manipulation of the river flow. It can be assumed that some of the effects of these suddenly dropped water levels had to do with the catchability of the fish. However, no quantitative relationships can be demonstrated with the data at hand. Some of the level manipulations had been completed before the fishing season got well under way, and others took place at various times and in various amounts and places. It is difficult to discern any effects upon the all-over average fishing success (figures 3 and 4).

Weather, moon phases, etc. At various times and by various persons, scientific or otherwise, many heated assertions have been made that fishing success depends upon the weather in general, the air temperature, the wind direction and velocity, the barometric pressure, the degree of cloudiness, the phase of the moon, something with a high-sounding title like "solunar cycles", or any one of a dozen other factors.

Eschmeyer (1937) found that the fishing was best when the particular combination of mild air temperature, clear sky, and light wind existed; but he was not able to tell which of these factors was the most important. For another season he reported (Eschmeyer, 1935) that he was not able to find a close relationship of the fishing with any of several meteorological factors.

Needless to say, in a study such as the present one, the influence, if such there exists, of any one or more of these various factors mentioned above could be assessed with extreme difficulty if at all. The first and foremost poser is the fact that the fishing success for any given day or week varied greatly from place to place within the general area. It is conceivable that some factors such as wind, air temperature, and cloudiness could also vary from place to place at any given time. It is further conceivable, therefore, that there could be a definite covariance between some of these factors and the catch of fish; but with the information available, it is almost hopeless to try to demonstrate any such relationship.

On the other hand, any such factor as the phase of the moon or the interactions of moon, sun, and tides, would be identical for all of the localities within this area at any given time. (To some extent this would be true also for the barometric pressure, since most of the storms in this region are generalized.) Therefore, any effect upon the fishing exerted by these factors should be uniform throughout the area. Obviously, it is difficult to ascribe poor fishing in one locality and concurrent good fishing in another to the same cause.

A set of fishing forecasts (for the summer of 1945) was chosen, one which appeared on a calendar in the form of shaded figures ("the blacker the fish, the better the day for fishing"). Although this forecasting system is only semi-quantitative in nature, a bit of mathematical maneuvering made it possible to obtain a crude statistical relationship between the forecasted fishing success and the actual recorded catch per hour (total averages, all pools), day by day throughout the summer. The correlation coefficient turned out to have a (very weakly significant) negative value. In other words, this particular forecast was wrong more often than it was right.

Elser (1953) obtained no significant correlation between catch and the data of "solunar" tables.

Depth of snow. There is some reason to believe that the depth of snow on the ice may exert considerable influence upon the amount of winter feeding by the fish and hence upon the fishing success. Heavy snow cover cuts down the amount of light entering the water, and presumably makes it more difficult for fish to find food (or bait).

The desirability of having data on the amount of snow cover occurred to the writer belatedly; no field measurements of snow depth were made during the creel census operations. Therefore, for any sort of computations regarding the relationship of snow depth to fishing success, reference could be made only to weather station records of "snow on the ground". These figures for the La Crosse Weather Station for the winter 1944-45, are shown in the graph of figure 3. In a very general way the changes in depth of snow on the ground at the La Crosse station corres-

ponded to the changes at other places throughout the area, since most of the winter storms are generalized. However, local precipitation conditions and such factors as blowing and drifting caused some variation in snow depth from place to place.

Assuming that the figures as graphed in figure 3 are representative of the entire area, it may be seen from the configuration of the two curves of this figure, representing the amount of snow and the fishing success respectively, that a broad relationship did exist whereby the fishing did tend to become poorer as the snow cover increased. The correlation coefficient was -0.37 (with P somewhat less than 0.01).

When the same set of figures for amount of snow on the ground was used in computing the correlation with the fishing success at some of the individual localities, the following results were obtained: Fountain City Bay, r = -0.64, P = 0.01; Lake City, r = -0.35, P = more than 0.1; Slough "22", r = zero; Gremore Lake, r = very small. The differences between individual localities may have been due in part to different effects upon different fish species.

With the same type of statistical treatment, some of the figures for the winter 1945-46 were: total (all pools), r = very small; Lake City, r = zero; Gremore Lake, r = -0.22, P = 0.2. Thus the correlation which apparently held true in the first winter cannot be demonstrated statistically for the second winter.

Relationships and correlations

Two successive years. The all-over average fishing success for the two winters 1944-45 and 1945-46 was fairly close to identical, being 0.54 and 0.46 fish per hour, respectively. As pointed out above, it is difficult to show that the difference was significant. For the 11 localities of table 16 (not including Winter Creek) for which there were data for the two winters, a mathematical correlation does not exist (r = virtually zero). The localities, therefore, which furnished good (or poor) fishing in the one winter were not necessarily the ones that furnished good (or poor) fishing in the next winter.

The configuration of the curves representing the week-to-week variation in fishing success for the two successive winters(figure 4) makes it appear that the trend of changes throughout the winter was similar for the two years. However, a calculation of the correlation coefficient (table 22) shows only a weakly significant correlation (r = 0.57; and P = 0.1). Furthermore, for each of two individual localities, Lake City and Gremore Lake, the week-to-week correlation coefficient is so small as to have no statistical significance even though there is a suggestion of similarity in the graphs of Gremore Lake for the two winters (figure 5).

The tendency of the fishing to fall off following the first few days or weeks of the winter season is perhaps significant and apparently is the common rule. It may be related to the fact that the snow cover is usually light at the beginning of the ice fishing period and tends to increase with successive snowfalls. Another factor which may make a contribution is that the fish at the beginning of the winter have not yet acquired the semi-lethargic state which they apparently possess later in the winter and therefore they are still doing some feeding. It must be remembered that the mathematical comparisons just referred to are made on the basis of corresponding calendar periods and not necessarily on a phenological basis. The onset of winter conditions and the course of events within a body of water throughout the winter may vary by a considerable period of calendar time.

Figure 6 presents a comparison of the week-to-week fishing success for the two consecutive summers. There is no statistical correlation and indeed the trends of the two curves have little or no visual similarity. To an even greater extent than in the winter, the summer conditions are apt not to follow the same calendar sequence year by year; particularly such things as flood periods may occupy dates which are considerably different one year from the next. This in turn has an influence upon other factors, such as water turbidity and water temperature. Therefore, it cannot be reasonably expected that the best (or poorest) fishing will fall within the same week in successive summers. Essentially the same statement has been made by Frey and Vike (1941).

Table 22. Fishing success, fish per hour, week-to-week averages, two winter seasons.

Week Beginning 1)	Total (All Pools) 1944-45	Total (All Pools) 1945-46	Lake City 1944-45	Lake City 1945-46	Gremore Lake 1944-45	Gremore Lake 1945-46
Dec. 16	0.97	0.65	1.02	0.42		
23	0.69	0.54	0.65	0.25	0.22	0.50
30	0.58	0.45	0.45	0.42	0.30	0.31
Jan. 6	0.50	0.34	0.28	0.41	0.32	0.41
13	0.51	0.49			0.36	0.30
20	0.37	0.45	0.24	0.28	0.16	0.26
27	0.53	0.59	0.25	0.42	0.36	0.84
Feb. 3	0.63	0.31	0.37	0.16	0.07	0.58
10	0.46	0.31			0.09	0.34
17					0.15	0.38
r =	0.57		small		small	
P =	0.1		not significant		not significant	

1) In 1945-46. In the winter 1944-45, the corresponding weeks began on December 17, December 24, etc.

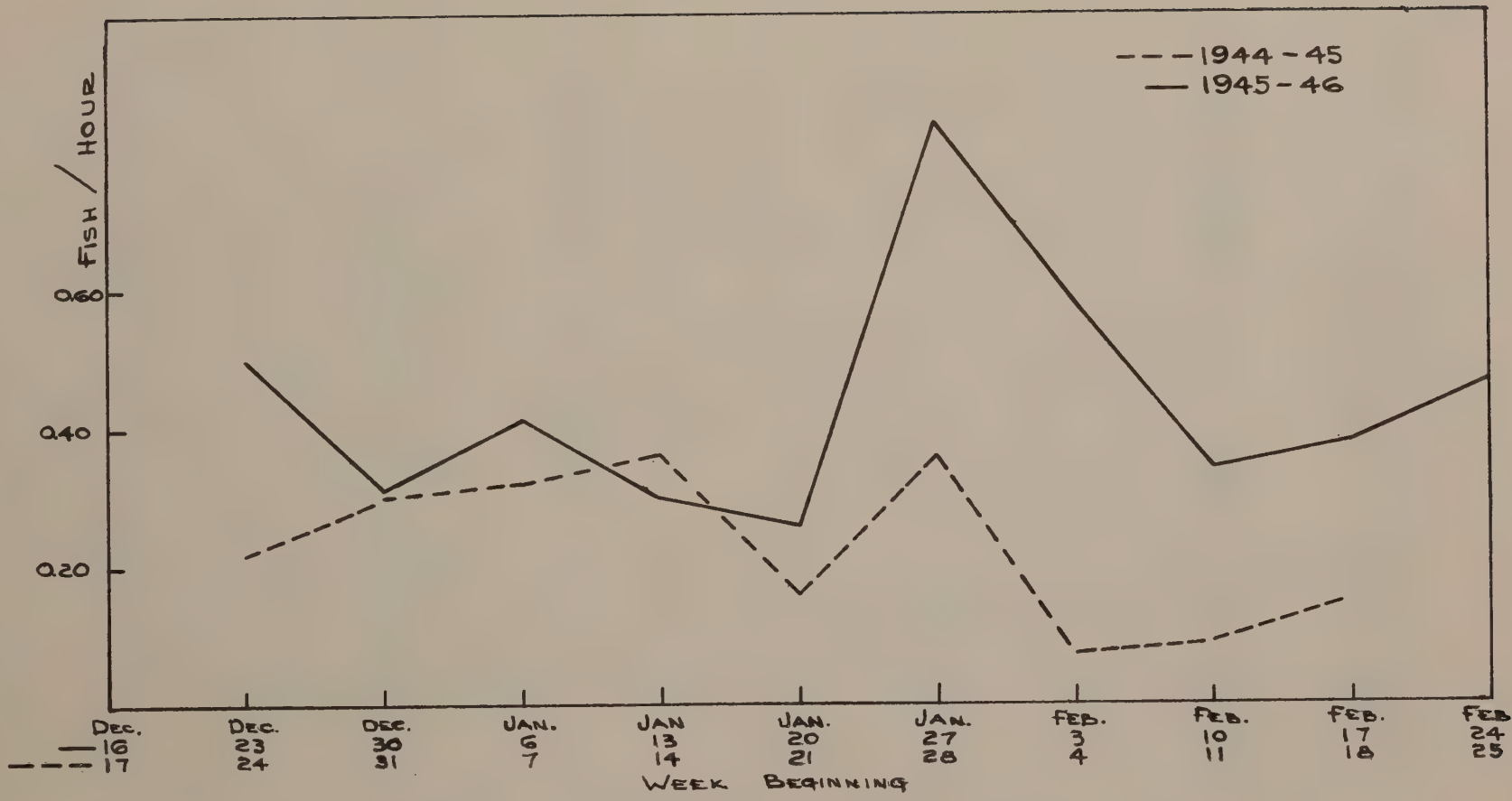

Figure 5. Week-to-week fishing success, Gremore Lake, winters of 1944-45 and 1945-46.

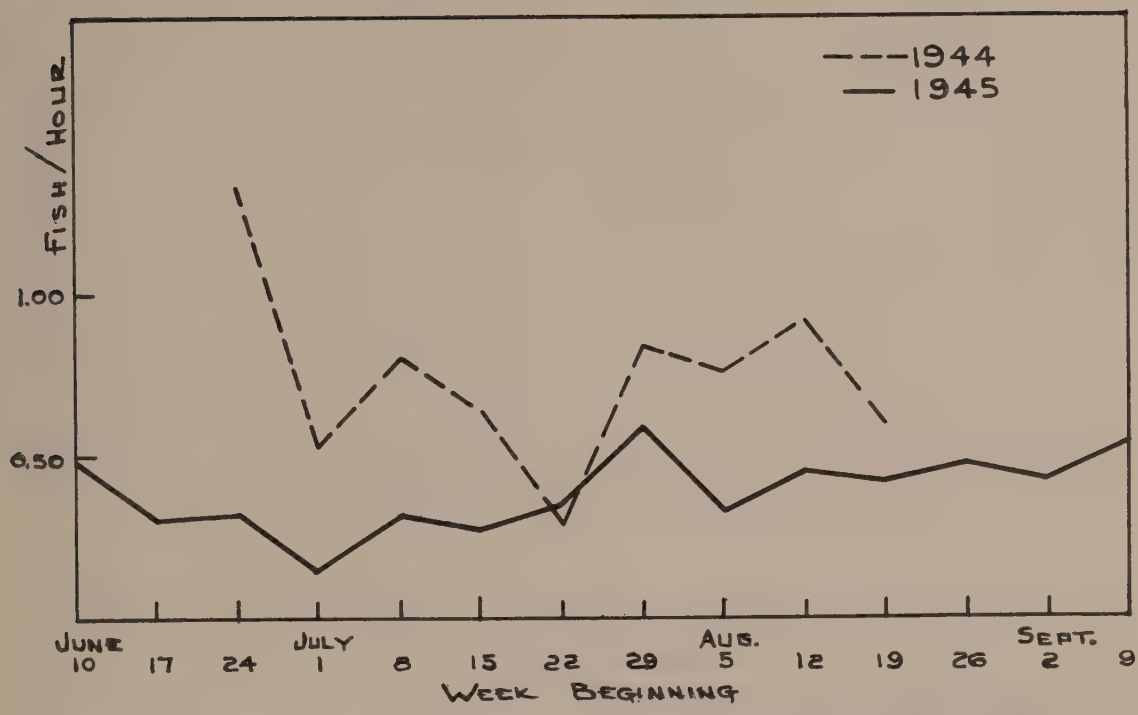

Figure 6. Week-to-week fishing success, Pool 8, summers of 1944 and 1945.

Sampling at intervals. As described above, all of the creel census here reported upon was performed on a day-to-day basis continually throughout the season. It was not possible to visit each locality each day, but a rotation scheme was used so that several individual localities within a larger area would be sampled on any given day, and any given locality would be sampled with a certain degree of regularity throughout the season. The aim was that for a larger division such as a pool or for the entire area as a whole, the day-to-day samples would be randomized and representative and would afford fairly complete coverage.

It is of interest to ascertain to what extent a given portion of the total season's sample, randomized as to time, would be found to be representative and typical of the whole. That is, could a sample consisting of the census on every fifth day, every seventh day, every tenth day, etc., be made to yield satisfactory over-all averages?

Table 23 presents some of this information for the summer of 1945. One of 5 days was chosen by lot. The figures for numbers of fish and numbers of person-hours for this day and every fifth day throughout the entire season were totaled. From this the average value of fish per hour was computed. This figure amounted to 0.48. This is reasonably close to the over-all average of 0.50. As it happened, the figures for every fifth day added up to 23.5 percent of the person-hours fished for the season rather than the theoretical 20 percent.

In the same manner, averages were computed for every tenth day (starting on a day chosen by lot), and for every Sunday. The tenth day total amounted to 9.0 percent of the total fishing hours (rather than the theoretical 10 percent), with an average fishing success of 0.51 fish per hour. The Sunday total amounted to 31.2 percent of the grand total fishing hours and indicated an average fishing success of 0.43 fish per hour. This last figure is lower than the everyday average, by an amount which probably is significant.

The idea is pursued further in the computations presented in table 24. Here are given the averages based on every fifth day, starting with each of 5 days in sequence; every tenth day starting with each of 10 days in sequence; and every seventh day, using each day of the week. Each of the figures in the column representing the fish per hour is of course to be compared with the 0.50 of the grand total average. For each of the fifth-day sets, and for each of the tenth-day sets, the average fish per hour is reasonably close to 0.50, the range of variation being from 0.45 to 0.57. When taken one day of the week at a time, the averages are higher than the grand total average for each day of the week except for Sunday and Wednesday, for which they are appreciably lower. It may be conjectured that Sunday fishing actually is done by fishermen who are less experienced and less skilled than those who fish throughout the week. Many families combine Sunday fishing with picnicking and boat riding, and therefore perhaps do not take their fishing as seriously as do the dyed-in-the-wool fishermen who fish on week days. The lowered average for the every-Wednesday set of figures possibly can be accounted for by the fact that in 1945 two major holidays, Memorial Day and the Fourth of July, fell on Wednesday.

Table 25 gives for each of 4 creel census seasons the average catch per hour based upon fifth-day samples. In each instance the particular day out of 5 was chosen by lot and the sample was constructed simply by using the field data which had been recorded on the given days. The last two columns in the table give a comparison of the average fish per hour for the season, as obtained in this manner, with the over-all total average. The figures agree fairly closely for each of the seasons except for the summer of 1944. Here the disagreement probably results from the small size of the total sample and hence of the subsample.

Further comparison of averages based on fifth-day samples, with total sample averages, may be had from table 26. Here several of the pools and a few separate localities are treated individually. The fifth-day series starts with May 5, the day chosen by lot, as above. With most of these individual pools as with the total (all pools), this particular series of fifth-days amounted to appreciably more than the theoretical

Table 23.--Fishing success of certain samples, as compared to the total average, summer 1945.

Sample	Fish	Person-hours	Per cent of total Person-hours	Fish/Hour
Every Fifth Day [1]	9,611	20,166	23.5%	0.48
Every Tenth Day [2]	3,974	7,736	9.0%	0.51
Every Sunday	11,444	26,804	31.2%	0.43
Total - All Days	43,093	85,699	100%	0.50

1) Starting with May 5.

2) Starting with May 9.

Table 24.--Fishing success of certain samples, summer 1945.

Sample		Fish	Person-Hours	Per cent of Total Person-Hours	Fish/Hour
Every 5th Day Starting with	May 1	9,783	17,797	20.8	0.55
	May 2	7,797	16,472	19.2	0.47
	May 3	7,431	15,614	18.2	0.48
	May 4	8,465	15,648	18.3	0.54
	May 5	9,611	20,166	23.5	0.48
Every 10th Day Starting with	May 1	4,722	8,542	10.0	0.55
	May 2	3,960	7,869	9.2	0.50
	May 3	3,729	7,605	8.9	0.49
	May 4	4,491	7,912	9.2	0.57
	May 5	5,160	10,994	12.8	0.47
	May 6	5,067	9,258	10.8	0.55
	May 7	3,837	8,602	10.0	0.45
	May 8	3,702	8,006	9.3	0.46
	May 9	3,974	7,736	9.0	0.51
	May 10	4,451	9,172	10.7	0.48
Every Sunday		11,444	26,804	31.2	0.43
Every Monday		4,304	7,691	9.0	0.56
Every Tuesday		4,209	8,196	9.6	0.51
Every Wednesday		5,749	13,063	15.2	0.44
Every Thursday		5,127	8,506	9.9	0.60
Every Friday		5,121	8,186	9.5	0.63
Every Saturday		7,139	13,253	15.5	0.54

Table 25.-- Fishing success of "every fifth day" samples, compared to total samples, four seasons.

Season	Every Fifth Day 1)		Total all Days		Per cent of Total	Fish per Hour	
	Fish	Hours	Fish	Hours	Hours	Fifth Days	Total
Summer 1944	359	606	2441	3430	17.7%	0.59	0.71
Summer 1945	9611	20166	43093	85699	23.5%	0.48	0.50
Winter 1944-45	2435	4878	13827	25594	19.1%	0.50	0.54
Winter 1945-46	1741	4056	8928	19555	20.8%	0.43	0.46

1) Starting with May 17, in Summer 1944.
Starting with May 5, in Summer 1945.
Starting with Dec. 22, in Winter 1944-45.
Starting with Dec. 1, in Winter 1945-46.

Table 26.--Fishing success of "every fifth day" samples, compared to total samples, summer 1945.

Pool or Locality	Every Fifth Day 1) Fish	Hours	Total All Days Fish	Hours	Per Cent of Total Hours	Fish/Hour Fifth Days	Total
Pool 4-R	536	1976	2265	7883	25%	0.27	0.29
Pool 4-L	413	1870	1775	7399	25%	0.22	0.24
Pool 5A	267	964	1081	3774	26%	0.28	0.29
Pool 6	820	1790	3237	8137	22%	0.46	0.40
Pool 8	683	1864	3198	8652	22%	0.37	0.37
Pool 9	808	1852	2127	5114	36%	0.44	0.42
Pool 10	3555	4248	18575	19529	22%	0.84	0.95
Pool 11	2192	4559	9119	19376	23%	0.48	0.47
R.R. Bridge at P.duChien	259	471	1514	2697	17%	0.55	0.56
Bathhouse Sl.	206	420	966	2196	19%	0.49	0.44
Swift Slough	907	1735	3814	7228	24%	0.52	0.53
Guttenberg Dam	699	1937	3039	8294	23%	0.36	0.37
Lacupolis	234	958	1111	4472	21%	0.24	0.25
Totals (all Pools)	9611	20166	43093	85699	24%	0.47	0.50

1) Starting with May 5.

20 percent of the total fisherman hours. This is at least partly caused by the inclusion of both Memorial Day and the Fourth of July. However, the fifth day averages for fish per hour agree fairly well in most instances with the averages based on the total samples. Agreement is not extremely good for pool 6 and pool 10, but even here the error is only about 12 percent.

Table 27 gives for most of the individual pools the every-Sunday averages as compared with the total sample averages. In each instance the result is like that for the total of all pools in that the every-Sunday average is substantially lower than the total average.

Tables 28 and 29 give information similar to the above for the winter of 1944-45. Several of the pools and localities are given individually in table 28, with a comparison of the averages for every fifth-day with the total averages. The starting day of the fifth-day series was selected by lot. For the most part there is a reasonably good agreement. There are a few exceptions, however, for which it is hard to account. A particular one of these is pool 10. Apparently this discrepancy in pool 10 came about because the fifth-day series by chance included several days when there were large numbers of fishermen on Gremore Lake and the fishing was poor. This is demonstrated by the figures in table 28 for Gremore Lake. Another individual locality for which the agreement was not very good is Bartlett Lake (in pool 6). This lake perhaps contributed to the discrepancy shown for pool 6.

Table 29 gives for the winter of 1944-45 the average fishing success for certain of the pools on Sundays as compared to that on all days. As in the summer fishing, the Sunday fishing is definitely less productive. Pool 10, for some unknown reason, provides an exception.

Table 30 gives for 3 pools the comparative averages for a fifth-day series and for the total for the winter of 1945-46. Here the agreement is remarkably good.

Possibilities for reducing the size of the sample. The effort, and therefore the cost of an extensive creel census operation such as this one could be reduced materially if the necessary information could be obtained by a smaller sample or a subsample. Whether or not it is possible to do this depends first of all upon what information is desired. The problem is simplified if it can be assumed that the only essential information is that dealing with averages, or to be specific, with the average fishing success for a given locality or area for a given season.

The discussion above leads to the presumption that for this area of the Mississippi River it is possible to obtain a reasonably accurate figure for average fishing success for a season by using some sort of a reduced and randomized sample without the necessity of obtaining complete coverage for every place and for every day of the season. Some discussion is made here of that point since it may be worth considering in setting up future creel census programs. However, it must be pointed out that these remarks apply specifically to a certain section of the Upper Mississippi River and to the years 1944-46. The extent to which they may be applied to some other time and place is a matter for the judgment of the researcher.

In the first place, even the large and extensive volume of data supplied by the creel census here reported upon, is in itself only a sample, since as stated, only a part (perhaps 30 or 40 percent) of the total fishermen during a given season were interviewed. For the purpose of all of the computations herein contained it has been assumed that this sample was random.

Although it has been shown that for the years involved the fishing success factor was not greatly different for two summer seasons and for two winter seasons, there is no justification whatsoever for assuming that the fishing success cannot and does not vary between any two years. It is a matter almost of certainty that fishing was very much better in the Upper Mississippi River in the years 1948-50 than it was in 1944-46. Therefore, it is not possible to write an absolute all-time average figure for the fishing success of this body of water on the basis of the average for any one season. If it is desired to know what the average for a long period of years may be, it seems that it is

Table 27.--Fishing success of "every Sunday" samples, compared to total samples, summer 1945.

Pools	Every Sunday Fish	Every Sunday Hours	Total all Days Fish	Total all Days Hours	Per Cent of Total Hours	Fish per Hour Sundays	Fish per Hour Total
4-R	622	2683	2265	7883	34%	0.23	0.29
4-L	589	2640	1775	7399	36%	0.22	0.24
5A	305	1284	1081	3774	34%	0.24	0.29
6	436	1472	3237	8137	18%	0.30	0.40
8	887	2475	3198	8652	29%	0.36	0.37
10	4165	4812	18575	19529	25%	0.86	0.95
11	2633	6092	9119	19376	31%	0.43	0.47
Totals (all Pools)	11444	26804	43093	85699	31%	0.43	0.50

Table 28.--Fishing success of "every fifth day" samples, compared to total samples, winter 1944-45.

Pool or Locality	Every 5th Day [1] Fish	Hours	Total all Days Fish	Hours	Per Cent of Total Hours	Fish per Hour 5th Days	Total
Pool 4-R	272	473	1916	3714	13%	0.58	0.52
Pool 4-L	646	1524	3320	7642	20%	0.42	0.43
Pool 5A	268	478	1334	2248	21%	0.56	0.59
Pool 6	163	526	1139	3004	18%	0.31	0.38
Pool 8	657	1006	3227	4949	20%	0.65	0.65
Pool 10	215	664	1717	2664	24%	0.32	0.64
Straight Sl.	90	260	573	1636	16%	0.35	0.35
Bartlett L.	68	240	438	1152	21%	0.28	0.38
Lake City	171	458	977	2455	19%	0.37	0.40
Lacupolis	104	178	565	1140	16%	0.58	0.50
Gremore L.	80	616	506	2136	29%	0.13	0.24
Slough "22"	398	590	1929	2642	22%	0.67	0.73
F. City Bay	278	478	1332	2238	21%	0.58	0.59
Total (all Pools)	2435	4878	13827	25594	19%	0.50	0.54

1) Starting with December 22.

Table 29.--Fishing success of "every Sunday" samples, compared to total samples, winter 1944-45.

Pool Number	Every Sunday Fish	Every Sunday Hours	Total all Days Fish	Total all Days Hours	Per Cent of Total Hours	Fish per Hour Sundays	Fish per Hour Total
4-R	451	1023	1916	3714	28%	0.44	0.52
4-L	523	1536	3320	7642	20%	0.34	0.43
5A	485	1061	1334	2248	47%	0.46	0.59
6	338	975	1139	3004	33%	0.35	0.38
8	1068	2298	3227	4949	46%	0.47	0.65
10	658	1015	1717	2664	38%	0.65	0.64
Totals (all Pools)	3922	8380	13827	25594	33%	0.47	0.54

Table 30.--Fishing success of "every fifth day" samples, compared to total samples, winter 1945-46.

Pool Number	Every 5th Day 1) Fish	Hours	Total all Days Fish	Hours	Per Cent of Total Hours	Fish per Hour Fifth Days	Total
4	726	2835	3606	13057	22%	0.26	0.27
8	351	624	1548	3056	20%	0.56	0.51
10	664	597	3774	3442	17%	1.11	1.10
Total	1741	4056	8928	19555	21%	0.43	0.46

1) Starting with December 1.

necessary to obtain information year by year for several years.

It also seems almost or quite impossible to select any given comparatively short period such as a day, a week, or even a month, and to consider it as representing an entire season. Not only does the fishing change considerably throughout the season but these changes are apt to occur at different calendar dates in different years, in accordance with phenological factors.

The next idea to consider is to what extent a given part of the area can be used to represent the whole. It has been shown above that for the season under consideration, fairly good mathematical correlation exists between the fishing success of certain localities and pools and that of the entire censused area. It would have been possible, for instance, to have obtained a reasonably accurate figure for the average fishing success of all pools for the summer of 1945 by ascertaining the figure for pool 10 alone (or pool 8 alone) and multiplying by the proper factor. Of course the catch is that there was no way of knowing in advance what this proper multiplication factor might be. Furthermore, there is no assurance that having obtained this factor for one year it could be used with accuracy for any other year. For any one of a number of obscure reasons, fishing might get relatively better or poorer in one pool than in another from one year to the next.

Furthermore, as shown above, fishing success from week to week or from day to day throughout a season might have been derived for the entire area, from that for an individual pool or locality. Again, there was no way of knowing in advance what multiplication factor would be needed and no assurance that the same factor would apply in some other year. Also, this procedure would not be without some considerable errors. For instance, the week-by-week fishing success in pool 10 in the summer of 1945 showed a good statistical correlation with that for the total of all pools. However, had the former been used to compute the latter, week by week, the calculated figure would have varied from the actual figure by as much as 50 percent for certain individual weeks. The same statement holds true for similar calculations using the weekly averages for pool 8.

There is even greater error in attempting to use any one locality as a representative sample of its pool than in using a pool (or locality) to represent the over-all area. There is a wide fluctuation of fishing success for any given period among the various localities in a pool, a part of which is based upon the difference in species composition of the catch between the localities.

For these waters, therefore, it would appear that accurate averages for fishing success can be obtained only by making a census every year (at least for a period of several years), throughout the entire season, and for all or most of the pools and the localities within the area.

There remains, however, the possibility of drastically reducing the effort and cost involved in the creel census by randomizing the sample on a daily basis. Figures given above make it appear that reasonably good averages for the season could be expected from a census conducted on one day out of (say) 5 throughout the season. With good luck, even every tenth day might produce a sufficiently accurate average for the season. Every fifth day would be much safer however. Every seventh day would be a poor choice because of the great variance in numbers of fishermen and fishing success throughout the days of the week.

For the sake of randomness, the beginning day of a fifth-day series should be chosen by lot, especially since each season has several holidays and also certain key fishing days, such as the opening day of the season, the Sunday before Labor Day, etc. Also, once decided upon, the schedule should be adhered to strictly, regardless of weather and other fishing conditions. It is possible to set up some sort of system of alternation, whereby the field worker could cover certain localities or portions of his territory on one series of fifth-days and another portion on another series.

While yielding the essential information regarding the all-over seasonal average, this system of reduced sampling probably would mean a reduction in the accuracy of tracing

trends throughout an individual season, and would give less accurate information regarding changes in the species makeup of the catch during the seasons and the relationships of physical factors.[2/]

Summary

1. Creel census was carried out on the section of the Upper Mississippi River between Red Wing, Minnesota, and Dubuque, Iowa, through 2 summer seasons and 2 winter seasons, 1944-46. The censuses of the summer of 1945 and the winter of 1944-45 covered 225 miles of river; those of the summer of 1944 and the winter of 1945-46 were conducted at one and three key fishing areas respectively.

2. A total of about 40,000 fishermen were interviewed in the summer, about 15 percent of the total fishermen were women; in the winter, about 5 percent.

2a. Over 90 percent of the fishing is done by "still fishing" techniques, using live bait.

3. The fishery is varied and involves at least a dozen species of warm-water fish. Bluegill sunfish and 2 species of crappie make up over half the catch, however. In some areas walleye and sauger are important.

4. Over a 5-year period (1945-49), following the census, an estimated 150,000 fishermen per year caught an average of about a half-million fish per year. Both the fishing pressure and the catch increased markedly during this period, over their amounts in the period 1944-46.

5. According to the census figures, the average angler had fished about 3.2 hours in the winter, and 3.7 hours in the summer, when interviewed.

6. The average catch per hour for 3 of the seasons was close to 0.5 fish, being about 0.7 for the summer of 1944. The average catch per fisherman-trip thus was around 2 fish. About one-third of the fishermen caught no fish.

7. The catch varied considerably, in species composition, from place to place. Some localities yielded almost exclusively walleye and sauger; others crappie and bluegill.

The winter fishery is more specialized as to kinds of fish than the summer fishing.

8. Fluctuations throughout each individual season were great and often abrupt. The summer fishing, in 1945, showed a tendency to improve after mid-July, although many localities did not follow the general trend. The winter fishing tended to be best in the early part of the winter.

9. There was some correspondence in the fishing trends through 2 successive winters, but a mathematical correlation is difficult to establish. The 2 summer censuses covered different extents of territory and hence are not strictly comparable.

10. The fishing success was not influenced greatly by the fishing pressure.

11. Worms produced better fishing than minnows, in terms of fish per hour. There was a great difference in the kind of fish caught; worms took mostly bluegills, minnows took crappies, walleyes, saugers, northern pike. Artificial baits did not rank high in catch per hour.

12. Fishing was better in the early morning and the evening than it was during the midday, in both the winter and summer.

13. Women were less successful anglers than men.

14. There is some evidence that water temperature was correlated (positively) with catch, at least within a restricted temperature range. Apparently different species respond differently to the water temperature.

15. Changes in water levels probably influenced the catch success, but the relationship

2/ Best and Boles (1956) present some pertinent information and conclusions regarding methods of subsampling.

is not clearly defined. In the summer of 1945, the improvement in fishing in the latter half of the summer, roughly coincided with reduced and stabilized water levels. There is evidence that different species react differently.

16. No correlation of fishing success with various meteorological factors could be demonstrated.

16a. It is scarcely conceivable that moon phases or other astronomical or astrological events could have had any great influence upon the fishing, since for any given day the fishing success varied greatly from one locality to another.

17. Apparently winter fishing was successful in a rough inverse ratio to the depth of snow upon the ice. This relationship was more evident in the winter of 1944-45 than in 1945-46.

18. In the winter fishing, the localities which had good fishing one year were not necessarily the ones with good fishing the following year.

19. Subsamples, using returns for a series of fifth (or tenth) days throughout a season showed, in general, good correlation with the total season's sample for the entire area and for most of the units of it.

20. Subsamples composed of the returns for a series of every-seventh-day (specifically for Sundays) gave, however, inaccurate results. Fishing success was poorer on Sundays than on weekdays, presumably because there were large numbers of inexpert fishermen on Sundays.

21. There are certain possibilities for obtaining seasonal average fishing success figures by the use of smaller samples than those taken in this study (the application is specifically to the area and seasons under discussion). Thus a great deal of the expense of the creel census operation could be avoided.

22. Sample subareas would give uncertain results because of the wide variation from place to place and from year to year.

23. Sample periods of time (such as a day or a week, or even a month, out of a season) also will not suffice because of the strong fluctuations with time.

Literature cited

Best, E.A., and H. D. Boles.
1956. An evaluation of creel census methods. Calif. Fish and Game, Vol. 42, pp. 109-115.

Dendy, Jack S.
1946. Water temperature and spring fishing, Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci., Vol. 21, pp. 89-93.

Doan, Kenneth H.
1944. The winter fishery in western Lake Erie, with a census of the 1942 catch. Ohio Jour. Sci., Vol. 44, pp. 69-74.

Elser, Harold J.
1953. A test of the solunar tables. Presented at a meeting of N.E. Div. Amer. Fish. Soc., Sept. 20-23, 1953. 12 pp. processed.

Eschmeyer, R. W.
1935. Analysis of the game-fish catch in a Michigan lake. Trans. Am. Fish. Soc., Vol. 65, pp. 207-223.

1937. A second season of creel census on Fife Lake. Trans. Am. Fish. Soc., Vol. 66 (1936), pp. 324-334.

1939. Summary of a four-year creel census on Fife Lake, Michigan. Trans. Am. Fish. Soc., Vol. 68 (1938), pp. 354-358.

1942. The catch, abundance, and migration of game fishes in Norris Reservoir, Tennessee, 1940. Jour. Tenn. Acad. Sci., Vol. 17, pp. 90-115.

Eschmeyer, R.W., D.E. Manges, and O.F. Haslbauer.

1946. Spring fishing on several TVA storage reservoirs, 1945. Jour. Tenn. Acad. Sci., Vol. 21, pp. 78-88.

Frey, David G. and Lawrence Vike.
1941. A creel census of Lakes Waubesa and Kegonsa, Wisconsin, in 1939. Trans. Wis. Acad. Sci., Arts and Let., Vol. 33, pp. 339-362.

Hart, J. S.
1940. Report of a season's angling, Cache Lake and neighboring lakes, summer, 1949. Ontario Fish. Res. Lab., Univ. Toronto. July, 1940. 14 pp. (mimeographed).

Hansen, Donald F.
1942. The anglers' catch at Lake Chautauqua near Havana, Illinois, with comparative data on hoopnet samples. Trans. Ill. Acad. Sci., Vol. 35, pp. 197-204.

Hiner, Laurence E.
1943. A creel census on Minnesota lakes. Minn. Cons. Dept., Fish. Res. Invest. Rept. No. 44. 20 pp. (mimeographed).

Pelton, John Z.
1950. Three years of liberalized fishing at Lake Alma, Ohio. Trans. Am. Fish. Soc., Vol. 78(1948), pp. 64-69.

Ricker, William E.
1945. Fish catches in three Indiana Lakes and Streams, Vol. 2, pp. 325-344.

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